

II. THE LIFE HISTORY OF THE RUFESCENT WOODCHUCK,
MARMOTA MONAX RUFESCENS HOWELL.

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INTRODUCTION

American naturalists have written many volumes on exotic forms. They have added to our knowledge of the habits of many foreign species which have never crossed our borders. They have travelled far, often at great expense and considerable hardship.

Or, within our borders, they have made our scarcer American mammals the main source of their monographic studies. In scientific journals they have given detailed observations and enlightening accounts of our lesser known beasts, forms mainly outside the ken of the layman. The American mammalogists have to confess amazing lack of knowledge of the life histories and activities of some of our most common mammals. These forms, by their very abundance, might give us, with hard work, our most thorough going studies. Has familiarity bred contempt, has abundance dulled interest, has constant presence produced casual accounts?

The woodchuck has been known to science for two hundred and thirty years yet we are still unfamiliar with many of its habits and details of life history.

The common woodchuck (*Marmota monax* group) ranges east to Nova Scotia, south to Georgia, west to Kansas and extends its range northwestward into Alaska, covering an area in excess of two million square miles. It is common over most of its range, even abundant over a great part. In spite of this great range, its large numbers and ease of observation, we still know little of its detailed life activities. In some ways the uncommon *Aplodontia*, restricted in range and relatively few in numbers, is much better known. The mountain beaver has been studied by fewer men, but far more thoroughly than has the groundhog.

Where the woodchuck has become a serious pest, drastic efforts have been used to check its depredations. Have these methods of control always been based on actual facts gleaned from a careful study of the life history of the creature? A thorough search of the literature fails to reveal the most essential facts of the woodchuck's existence, data usually necessary in any successful warfare against an animal. Scientists have not consistently attempted to investigate such pertinent topics as the time spent by the young in the nest, behavior and description of the young prior to their emergence from the burrow, seasonal growth, the listed foods and feeding habit. These are important phases. Without a knowledge of them, we must perforce be limited in our attempt at the control of most mammals.

In spite of this seeming lack of interest in the woodchuck, some writers have contributed in no small way to our knowledge of this rodent. To mention all who have published notes on this animal would be to include a roster of American vertebrate naturalists. To cite a few, Merriam (1884), Seton (1928), Fisher (1893), and Howell (1915) have all contributed to our understanding of the animal.

The present study has been made in the hope of filling in some of the huge gaps that still exist regarding our knowledge of this form; to help complete certain chapters in a life that is in reality little known.

Since 1923 the writer has been in a territory exceptionally favorable for the study of woodchucks, and has gathered notes on these animals every year except in 1926. Most of the observations herein recorded were made in 1931 and 1932.

ACKNOWLEDGMENTS

To Dr. A. H. Wright, for his enthusiastic support and suggestions, I owe much. He has made it possible for me to spend long hours in the field on this particular problem. Edward Drake fed captive animals while the writer was unable to do so, and secured a number of specimens. My wife, Nellie Rightmyer Hamilton, has been invaluable in her hearty cooperation in caring for young animals and in her aid in photography. Dr. Robert Matheson determined the arthropod parasites while Mrs. T. R. Allen of the Botany Department at Cornell University aided me in the determination of several plants.

Finally, to Mr. Harold Rightmyer, I wish to express my deepest gratitude for the part he played in this study. Possessed of uncommon stalking ability and unrivalled marksmanship, he was responsible for over three hundred and fifty of the animals used in this study. Without remuneration of any kind, he repeatedly aided me in the excavation of woodchuck burrows, a thankless job at best. He has spent long hours collecting animals in the field and has aided me materially in the construction of cages suitable for breeding purposes. We have spent many pleasant days afield, constantly searching new covers or exploring the old for the "little red monk of the clover patch."

REARING ENCLOSURES

In 1931 woodchucks were kept in large cages at the Cornell University Insectary. These cages, designed for rearing insects and other

work in experimental entomology, are approximately twelve by eight feet, and over ten feet in height. The walls are composed of fly screen, and reinforced in part with hardware cloth. In the bottom, under a layer of several inches of dirt, half-inch poultry wire was laid down. Several such cages were used, and several individuals were lost because of their ability to tear through the sides or bottom of the enclosure. On the floor of the cage, large wooden boxes, with top knocked out and inverted, were placed. The opening was made by the woodchuck, which burrowed through the dirt to gain an entrance.

Inasmuch as these pens lacked the strength necessary to house animals for any length of time, new pens were designed in 1932. Seven were constructed. The wire enclosure, six feet in length, three feet wide and seventeen inches high, was made of specially constructed fox farm wire, No. 11. This had a mesh one by four inches. Some of the wire used had a mesh of one inch. A length of galvanized steel piping, such as is used in furnaces, eight inches in diameter and nineteen inches in length, led from the feeding pen to a hole cut in the side of a large galvanized garbage pail, twenty three inches high and sixteen inches in diameter. This made an effective "burrow" leading from the nest chamber in the pail to the feeding enclosure outside.

The lid of the pail was kept securely in place by a piece of heavy wire, securely fastened to one handle of the pail, and run through the handle on the top, then fastened to the other side by a stout swivel snap. (Plate XVII). This allowed easy access to the nest chamber in a moment's time. The whole apparatus was placed in an excavated area in a large straw stack, on a level with the ground. Over the pail, runway, and a foot or two of the feeding enclosure, straw was placed to the depth of a foot or more, depending on the temperature. This gave warmth to the enclosure, which was very necessary when the young commenced to arrive. Temperatures well below freezing were experienced nightly during early April when studies of the young animals were being made.

This description of the pens is given in the hope that a design such as outlined may prove of value in breeding or raising other fossorial animals. It is worthy of note, that in three cages equipped with a length of pipe to simulate the burrow, woodchucks successfully raised their young. In four enclosures without such a tunnel all the young were abandoned shortly after birth, even though the cages were placed in the quiet semi-dark basement of a large barn.

PRESENT AND FORMER STATUS OF ABUNDANCE

There can be little doubt that those who are familiar with woodchucks and their ways, readily believe that the animal yearly becomes more abundant. With settlement, forests are doomed, and with the disappearance of trees come the meadows and pastures. Small wonder that the woodchuck, an uncommon animal at one time, has thrived and multiplied, not in spite of man, but because of him and in all probability will continue to thrive and increase in numbers.

The advent of the high powered rifle, the spread of inexpensive motor cars and the development of improved roads along portions of territory rich in woodchucks had the combined effect of bringing about yearly the untimely death of thousands of woodchucks. This is the case in spite of state laws prohibiting the shooting of firearms from an automobile or from the highway. Woodchucks have become so accustomed to cars, trains, and the like, that they take these as a matter of course. They fear these automotive contrivances but little, if at all. If the animal does take to cover when a car stops, its inquisitive nature usually brings it to the mouth of its burrow to meet its doom.

In spite of this destruction, the ever increasing disappearance of timber, which is replaced in time by fields of clover, alfalfa, truck crops, and hay fields, more than atones for the deadly toll of the sportsmen.

HABITAT RELATIONSHIP

There can exist but little doubt that the woodchuck was once a forest animal and has taken up its abode in open country since the advent of the white man. It has forsaken the heavily wooded areas and lives on that borderline which still supports trees, on the one hand, and wide meadow and pastures on the other. With the clearing of the forest by man, and his consequent extermination of the wolf, cougar, and other large predators of the east, the little "whistle-pig" has multiplied and spread beyond belief. Throughout its range it is today the most abundant animal of its size.

Throughout central New York, a land of mixed hardwoods, rolling pastures, occasional swampy tracts, and numerous streams and lakes, it finds its promised land. Here it occurs in dense woods, bottomlands, and all the rich intervening areas. Woodchucks seem to prefer flat, or slightly rolling land, well studded with rocks or large stones.

In such country the densest population is recorded. In the high bluffs of Kentucky, where soil is at a premium in much of the eastern part of the state, I found woodchucks using the fissures in the rocks for den sites. In eastern Massachusetts, where the soil is remarkably sandy, the burrows were observed to penetrate far deeper than in the region about central New York.

The effect of climatic conditions, such as droughts, mild winters, etc., must play some part in the animal's existence. The late summer of 1931 was noticeably dry, indeed a drought threatened the crops and did considerable damage in central New York. It was noticed, when averaging figures for a study of the rate of growth, that young collected in September of 1931 averaged consistently somewhat lighter than in those animals collected a year later, when copious rains and a good growing season combined to make for rank growth of the food plants commonly used by this species. The average weights of nine young collected during September of 1931 averaged four pounds, nine ounces, while a like number, collected over the same period a year later, averaged five pounds, fourteen ounces.

The nationwide drought of 1930 had little effect on the population of woodchucks in the following year, when they seemed to be more abundant than ever.

Mild winters cause only sporadically a premature awakening of hibernating woodchucks. At the first cold snap they resume their torpor-like sleep.

No definite factor tending to decimate the woodchuck population and to leave them a weak remnant of their former self has yet been noticed to the satisfaction of the author in ten successive years' observation about central New York, whereas Spears maintains the contrary opinion. He said in 1903:

"Like Rabbits and Hares, woodchucks have years when they are 'everywhere,' and then follow years of scarcity. Waves of animal life sweep across the foothills of the Adirondacks from time to time... So with the Woodchucks. For a few years they are hardly noticeable anywhere, then some summer, when the grass is mowed, the meadows are alive with them."

NUMBERS

Seton (1929) has gone to some length to point out the probable woodchuck population of New York and New England, on the basis of

reports by Merriam and Burroughs. Briefly, he quotes Merriam as capturing 33 woodchucks in one large meadow during a single season. Burroughs and his neighbors accounted for about 200 "chucks" on a hundred acre tract during a single summer. The whole region was similarly populated. This implies 300 to the hundred acre tract, or 2500 to the square mile. Seton, on the basis of these figures attempts to demonstrate that New York and New England, with 100,000 square miles of woodchuck range, should have 200,000,000 woodchucks.

The writer has travelled extensively throughout New York and New England. Notes have been kept on the vertebrates encountered, and during the past year or two, especially on the woodchucks. He considers that Tompkins and Tioga Counties, in central New York, have the richest population he has ever encountered in any area. More than one hundred animals have been seen in an April morning from the road starting three miles east of Ithaca, N. Y., and passing through Brooktondale, Caroline, Richford, and thence to Candor, a distance of approximately seventeen miles. In less than two years, Mr. Harold Rightmyer, Mr. Edward Drake, and the writer have taken considerably over five hundred "chucks," without making any serious depletion of their numbers. The animals were usually sighted from the road, when a little stalking usually brought the observers within their range. In localities especially abounding in woodchucks one can count in a stretch of a mile of road, including two hundred yards to either side, as many as one hundred tenanted burrows. Individual fields will yield a higher percentage, while wooded slopes are not so prolific of dens.

Drake trapped forty-three animals in a period of two years on a tract of twenty acres and made no apparent effect on the number of animals.

In one field consisting of three acres, Rightmyer and the writer counted over thirty separate dens. These were all in use. Another small field less than an acre in extent contained eleven sets of burrows. Throughout this area there must have been five woodchucks to the acre, a much higher percentage than Seton gives, and considerably higher than is to be generally encountered in the area we have under consideration.

There are many extensive areas throughout the state where woodchucks are absent or very scarce. It is unlikely that throughout the state, taking good and bad country together, there is more than one

woodchuck to every three acres, and probably there are less than this number. Mr. Harrold Rightmyer, who has hunted woodchucks extensively in the Adirondack region and in central New York, has figured independently that there is one to every two acres. On the basis of our combined estimates, there would exist a "chuck" population of perhaps fifty to the square mile, or between two and three million woodchucks in New York State. There is of course no exact way of determining the numbers, nor does it matter.

So far as it can be ascertained, no plagues, due to the unusual increase or destructiveness of the creature, have ever visited the woodchuck. There is nothing in the woodchuck tribe which parallels the terrific plagues affecting mice and ground squirrels in western America.

MEANS OF DETECTING PRESENCE

TRACKS

During late February and March, when the animals are wandering widely, the tracks are often observed on the snow. The four-toed fore foot and slenderer five-toed hind foot serve to distinguish it from the raccoon, which has five prominent toes to each foot. Both fore and hind foot are closely bunched in a running individual and the distance between the sets is normally twelve inches. In a walking animal about four inches separate the tracks.

FECES

It is seldom that the excrement of the woodchuck is encountered about the den, but when it is, the long blackish droppings are not readily confused with those of any other animal. The scats are usually deposited in a dry chamber within the burrow or buried in the mound at the entrance hole, hence are not frequently seen. I once found a dropping thickly studded with the seeds of *Prunus serotina*, but when it was broken up it failed to reveal any insect remains. Had it not been known at the time that woodchucks commonly feed on wild cherries, the dropping might have been mistaken for that of a skunk, for invariably *Mephitis* has insect remains in its droppings.

The scats vary in shape and size, but usually are somewhat long and rounded, or slightly coiled. An inch and a half to three inches is normal, but one very long dropping measured five inches.

BURROWS AND TRAILS

A woodchuck burrow is kept well cleaned out; a fresh mound of dirt at the entrance is usually to be found. We do not expect to find this new earth at the mouth of dens occupied by skunks or rabbits. Likewise the distinct trails through the grass and the closely cropped herbage are sufficient indications of the nearness of woodchucks.

Tooth and claw marks on small trees in early spring, principally about the entrance to dens, are indications of the presence of the woodchuck. The animal scratches the bark from these small trees of the hedgerow. When the incisors are used, they do not make clear tooth marks as do those of mice and rabbits, but leave a ragged appearance to the bark.

INDIVIDUAL CHARACTERISTICS

INTELLIGENCE

The woodchuck, like most other rodents, low in the scale of mammalian life, is not over-endowed with intelligence. Excluding the skunk, there is no other mammal approaching its size that is so readily trapped. An individual will sometimes studiously avoid traps, repeatedly jumping over a pair set in its doorway, but for the most part, these rodents will blunder into any contrivance set for their capture. Woodchucks are easily stalked and shot. When "holed" by man, the animal usually is driven by curiosity to pop out of the burrow to its frequent undoing.

Its strength is great for a small animal. Time and again individuals have pulled out of large steel traps that would easily hold a large dog or raccoon. If not better equipped with physical powers in the spring than the fall, it is certain it can pull itself loose from traps more readily at this period. Yet many woodchucks will not learn to avoid traps, even though they have previously felt the steel jaws a number of times.

VITALITY

So far as I am aware the recuperative powers of a woodchuck are without parallel among the smaller mammals. It is no uncommon experience to collect animals that have a foot missing. I once shot a large male in the late summer whose left fore foot and right hind foot

were nothing but black stubs, the whole foot missing at the ankle. Yet the animal was in excellent condition.

Bullets appear to effect them but little, unless it be a head, heart, or lung shot. Even then they sometimes manage to crawl within the den, to die a miserable lingering death in its dark recesses. It is of interest to note that frequently, when an individual is mortally shot, it will drag itself to the entrance burrow a day or two later and die at the mouth of the burrow or on the mound. Animals that are shot in the belly or groin with heavy cartridges which may scatter their viscera widely can run to the den, often fifty yards distance, and make their escape.

Sometimes individuals were collected with huge festering sores, the result of poor marksmanship on the part of a hunter. Again, animals are occasionally met with that have a part of the intestine *hanging from the body*, yet sufficiently healed for them to lead a partially normal existence.

COURAGE

No one can accuse the woodchuck of lacking anything in this respect. His courage is all there is to be desired. I have caught several in the open fields that, when run down, have turned and attempted an attack. Mr. Edward Drake, who once shot a young individual, had the animal run directly at him, chatter its teeth, and drop dead at his feet. They are frequently more than a match for a larger dog, and will soundly trounce a terrier much heavier than themselves.

SOCIABILITY

It has frequently been stated that woodchucks are solitary animals shunning their kind and permitting no other woodchuck to enter their domain. Ernest C. Adams, writing about this creature in "Recreation" for May, 1902, says, "Though a woodchuck may have two or three burrows which he occupies at different times in a year, there is never more than one animal in a burrow, except the mother with her young."

This statement needs considerable qualification. It is true that woodchucks are more frequently solitary in their residence, but it is far from uncommon to see more than one adult in the same hole in times other than the breeding season. There is ample evidence that

two, not necessarily a pair, remain together throughout the summer. As a matter of fact, there may be as many as three or four in the hole at the same time.

On May 1, 1931, at Candor, N. Y., I saw three sets of burrows that had a pair of "chucks" to each set. On June 4, 1931, three adult males were collected from the same burrow within a few moments of one another. This set of holes was under observation all the time, and no animals entered while I was collecting the three. On June 11, 1931, Mr. Edward Drake saw two adults at the entrance of their common hole. On August 20, 1932, I saw about twenty "chucks" in the forenoon. Several of these were in pairs at the common entrance hole to a burrow. A week later two "chucks" were seen at a single hole. September 8, 1932, was an ideal day for "chuck" hunting. About thirty animals were observed and three pairs were seen at the common entrance to their hole. During early July of the same year, Mr. Harold Rightmyer took ten woodchucks from one hole in the course of a week's hunting. It is impossible that all were tenantry this burrow at the same time. It was a long established excavation, and probably so attractive to the animals that they kept coming as soon as it was vacated. It might be that several lived in the hole at the same time.

It is certain that they hibernate in pairs at times. Bachman (1846) records that two dormant woodchucks were found in a den opened in early November in Rensselaer County, N. Y.

Playfulness is frequently exhibited in young animals about the den. I have never observed among older animals any tendency to frolic whereas Gianini (1911) witnessed on one occasion a manner of behavior which could be interpreted as a game of sorts.

It appears so unusual that I quote it in its entirety.

"On the morning of May 9, while returning home after a tramp in the woods to note the new arrivals in the way of birds, a friend and I suddenly came in sight of a pair of woodchucks at play. We had not yet come out of the edge of the woods, and the animals were at the edge of their burrow in a large meadow some distance away. They would sit up, take hold and wrestle; and we noticed that when one was thrown, he usually landed in the hole and disappeared from sight for a second or two. We watched this performance for a considerable time, and at first thought it accidental when one animal or the other landed in the opening, but it was repeated too many times not to have been intentional.—The woodchucks were probably young of the previous year.—I have watched woodchucks a great deal—but never before have I seen them at play." (Quoted from Seton).

LENGTH OF LIFE

Probably the natural span of life of a woodchuck is four or five years. Mammals supposedly live four or five times as long as the period required to reach sexual maturity. Woodchucks become mature, in many instances, when the animal is in its second spring, or about a year old. I know of no individual of this species that has been kept in captivity for longer than three years. If some individuals attain a weight of over seven pounds the first fall, when they are only five or six months old, it seems probable that the normal life span would not pass beyond the fifth year.

If a few of the marked individuals the writer has liberated when young can be recaptured from time to time, some useful data on this subject may be forthcoming.

VOICE AND OTHER MEANS OF COMMUNICATION

The woodchuck has a well developed voice, that is only heard occasionally or at a very short distance from the animal.

Most familiar is the whistle, common to all marmots. This is a sharp short note, which is preceded by a muffled "phew." This latter note is very low, and one must be close at hand to detect it. The whistle is frequently followed by a rapid warble, which sounds like "tchuck, tchuck, tchuck" and grows fainter at the end. The whistle is usually given in the mouth of the burrow, but may be heard from feeding "chucks" as they sit up to watch their respective domains. The whistle may be of two syllables. Many hunters have told me that once the "chuck" gives this whistle from the burrow, it is useless to wait for a shot at that specimen. This is not always the case, for frequently their curiosity gets the better of them. Cautiously the head is thrust out and finally the animal appears, even though it may have whistled intermittently for three or four minutes.

Once, while hunting "chucks" in the early fall, I heard one whistle. The call was taken up by a succession of "chucks," until five individuals were whistling. They actually made their small field ring with their combined efforts. Young animals develop this note when they are about six weeks old. The call may be heard from a distance of two hundred yards, but it is not so pronounced in the rufescent woodchuck as in the hoary marmot. This latter animal is said to have a whistle which may be heard from a distance of more than a mile

(Howell, 1915). This vocal accomplishment of the woodchuck has earned it the name of "Whistler" in the west, but this appellation is more strictly applied to the Hoary Marmot of the Rockies. The woodchuck is called "Siffleur" by the French Canadians, in allusion to its call.

Another noise, not strictly a note, that is common to all woodchucks, is that made by grinding the cheek teeth together. This grating noise may be heard at the age of four weeks and ostensibly denotes anger or fear. It is a very pronounced, albeit not a loud, noise.

A muffled bark, not unlike that of a small dog, was emitted by captive animals.

EMISSION OF GLANDULAR SECRETIONS

Lying just within the vent are three white-capped orifices, opening into the three anal glands. Within these are housed the secreting cells that give to the woodchuck its peculiar and characteristic odor. In anger or fear, these caps are everted, and the specific odor may be detected. When one picks up a woodchuck by the tail, the odor is frequently pronounced.

Probably the most important function of these glands is their use as a means of communication. On August 30, 1932, while I lay at the edge of a large clover field in the gathering dusk, waiting for the animals to make their appearance, I was suddenly struck by the pronounced odor that assailed me. This was the familiar smell always associated with woodchucks. Simultaneously three animals appeared, all within a distance of fifty yards of one another, and stood for a moment at the entrance to their burrows. Soon several more made their appearance, preceded by the characteristic odor. I spoke to my companion, asking if he had noticed the smell. He replied in the affirmative and further stated that he had noticed this not infrequently, but more especially when he had waited for some time for the "chucks" to commence foraging. In every instance the release of the odor was the signal for the appearance of two or more "chucks." I had never noticed this smell so pronounced, but possibly a combination of wind and atmospheric conditions made the observation possible at the time. In all likelihood this observation could be duplicated any evening in territory rich in woodchucks providing the elements were propitious.

It is unlikely that marmots have "odor posts," so common with members of the Canidae. At any rate, I have never seen any instance of such. It is frequently an easy matter to determine the presence of woodchucks in a burrow simply by the characteristic smell.

MOVEMENTS

When not alarmed, the normal gait of the woodchuck is a slow walk. It frequently stops to examine a tender shoot, or sits up on its haunches to scan the field for foes. When alarmed, the woodchuck's movements are hasty, and consist of either a fast walk or a loping gallop, which take it over the ground at a surprising speed for such an apparently clumsy creature.

SPEED

On a number of trips afield I have had the speed of frightened woodchucks well demonstrated, as they ran for their holes. Once I chased a feeding woodchuck that had wandered eighty yards from its burrow. I had just fired at the animal and missed; and knowing there was no hole nearer than the one it had started for, I started in pursuit. The animal had about a fifty yard start, and managed to keep that lead throughout the chase, although I tried desperately to overtake it. Assuming that it took me about fifteen seconds to cover the eighty yards, the animal had averaged then ten miles per hour in its dash for safety. This is perhaps an excessive speed, and could be maintained for a minute perhaps, but surely not for a longer period. I have never seen one run faster.

A number have been run to earth in the field and captured. When capture is imminent, the fearless creature will often turn on its tormentor and show fight. I have seen dogs turned back by this show of courage, and most every farm boy who owns a mongrel dog has noted the same spirit on the part of the woodchuck.

Early in the spring of 1931, a large woodchuck was observed pursuing a smaller individual. They were moving at a fast rate and were probably equalling the best efforts of an average man over rough ground.

Woodchucks do not have the endurance for long trips at high speed. The animals do make extensive treks in the early spring, but the tell-tale tracks in the snow show that they seldom run at this time.

SWIMMING

Woodchucks, like all other mammals that have not assumed the upright posture, are good swimmers. It is amply testified by many writers that they enter the water of their own accord. The most remarkable instance of this character is recorded by Robinson (1923), who says:

"In front of my home in Nelson County, Virginia, the James River is over 100 yards wide, and, at that particular spot, the river bottom is all on the north side, the south side being a precipitous, rocky bluff. In this bluff, there are a number of woodchucks; but the vegetation . . . does not furnish them with a food supply comparable to that on the cultivated land on the opposite side. They, therefore, frequently swim across, feed on corn, clover, melons, etc., and then swim back. I have several times seen them do this; and on June 18, 1899, I overtook one with a boat and captured it in the middle of the river."

I once shot at a "chuck" near Locke, N. Y., during mid-June. The animal had been feeding in a marshy tract bordering a stream, twelve feet in width and knee deep in depth. Without any hesitancy, the animal ran into the water and swam to the other side. So alarmed was it that it did not waste any time but, in a hasty retreat, disappeared in the brush on the opposite shore.

DIGGING

The woodchuck is a digger *par excellence*. His stout fore paws, armed with strong black claws, enable him, in soft ground, to keep well ahead of an ambitious digger for some little time, inasmuch as his custom is to fill in behind him, when pursued. The excavations by this animal are accomplished with powerful alternate strokes of the fore feet. The stout skull is an important tool of the animal while digging, as comparison with a skunk would indicate. An adult woodchuck's skull weighs about forty grams; a skunk with the same body weight and of nearly equal size has a skull weighing one half that of the rodent. Yet the skunk has a brain capacity equal to that of the "chuck." In other words, with strictly fossorial animals or those that do a considerable amount of digging, the skull is heavier and more massive than in those that do not dig, or burrow but little.

It long puzzled the writer how the animal could bring to the surface, from the innermost chambers and ramifications of its burrow, stones weighing more than two pounds and perhaps several hundred pounds

of dirt, in the larger excavations. I am not at all sure of the method yet, but observations on numerous animals working at the entrance have clearly demonstrated a few facts. Woodchucks employ the head, but more especially the facial region, to remove the larger stones from the chamber. Certainly the hind feet, which are noticeably less strong than the fore legs, are yet stout enough to push backward and out any loose dirt that accumulates here. Possibly this action explains the irregular bare patches on the snout and forehead so frequently encountered in woodchucks. This glabrous area is more common to the females than the males although both sexes engage in the strenuous duties of home building.

TREE CLIMBING WOODCHUCKS

So much has been published of late (*Journal of Mammalogy*, May and November, 1925) on the woodchuck as a tree climber, that it seems of little value to comment further on this rather common phenomenon. However, my observations may lend some facts of interest to the history of this subject and possibly lay the matter forever at rest.

On April 7, 1924, I was trout fishing near Newfield, N. Y., in a rather dense alder thicket, bordered by large hardwoods on either side. Presently I heard a movement in the thicket and stood still, hoping to discover the cause of the noise. My surprise was great when I saw a good-sized woodchuck climbing a large maple, about fifteen inches through the trunk, perhaps to obtain a better view of the queer biped along the stream. The animal climbed hand over hand, with evident ease. It stopped when about twelve feet from the ground, and below the first limb. After a few moments rest, it commenced to peer about, first to the right, then to the left. I approached it slowly, inadvertently making considerable noise on the way. As soon as it saw my intentions, it "froze" to the trunk of the maple, pressing close and flattening the hairs. "Glued" to this spot, it allowed me to touch it. I then backed away and gave the tree a smart rap with a stick. It fell out of the tree in its haste to get away, and ran off through the woods at a great clip.

On May 12, 1931, at Danby, N. Y., in company with Mr. O. C. Van Hynning, I witnessed a woodchuck leisurely climb a leaning wild cherry tree, to feed on the blossoms. The animal appeared exceptionally tame. Examination of the tree showed the woodchuck had been using

it for some time, perhaps as a point of observation as well as a dinner table.

During early September, 1924, I surprised an old woodchuck that was sunning itself in the top of a wild cherry. In its haste to depart, the animal lunged from its perch, about twelve feet from the ground, and quickly disappeared into a nearby hole. Possibly he had been feeding on the ripe fruit, as they are known to do.

It is not an uncommon sight to see the animals perched atop a fence post, surveying their domain. Whether this is done as a protective device, to better scan the fields for enemies, or whether it is a playful habit indulged in, I cannot say.

While driving through western Pennsylvania in early July, 1931, I saw a young woodchuck run across the road. I quickly stopped my car and gave chase. The animal ran through heavy brush, but I slowly overtook it. Sensing ultimate capture, and apparently in a section devoid of accessible holes, it did the next best thing, and ascended a small oak. It climbed to a height of twenty feet or more with remarkable celerity for such a heavy-bodied animal. I attempted to dislodge it without success. Unfortunately time did not permit of further observation to determine the manner of descent, but it is said that they can descend the perpendicular trunks of large trees, head first (Langdon, 1880).

PERIOD OF ACTIVITY

In general, woodchucks are most active outside their burrow during the early morning hours, and again late in the afternoon. They may, however, be observed at any hour, under favorable weather conditions, but show a decided preference for the above periods. Many pages of notes have been accumulated regarding the number of animals observed daily, together with the time spent in the field. This will best be treated by months, as the daily activity apparently changes with the season.

MARCH

Paradoxical as it may appear, records show that the woodchuck is highly nocturnal at this season. During this early period it is likely to be more active in the night than during the day. This is amply recorded by their telltale tracks on the snow, and by their subnivean wanderings. On March 15, 1931, the ground was covered by several

inches of snow. I visited a series of woodchuck burrows shortly after daybreak, and the ground was literally covered with their tracks. New tunnels had been opened in the snow, and signs of their wanderings the previous night were everywhere. Yet, the same tract at dusk of the previous day had shown little indication that "chucks" were present. The temperature during the night was well below freezing.

On March 19, 1932, about an inch of snow fell between 5:30 and 8:00 P.M. I placed traps at the entrance to several holes just before dusk and closed several other shafts by stamping that had recently been opened. The traps were visited at 7:30 o'clock on the following morning, when the temperature stood at 20° F. Several hours earlier it was 3° lower, yet a woodchuck was caught in one trap, and several holes, closed tight the previous evening, were opened.

Throughout the 20th, snow flurries fell through the day, with a temperature hovering above the freezing point. Two traps had held "chucks," and I tracked one for a quarter of a mile through the snow. In this trip it had opened, or entered, eight burrows, possibly in the quest for a mate. These holes were situated in a hedgerow of wild cherry (*P. serotina*) and at the entrance of each hole where such young shoots grew, they had been clawed or bitten by the animal.

On March 23, 1932, a female was taken about 6 A.M., and two males at 5 P.M. The temperature at these periods was slightly below freezing. On March 24, 1932, a woodchuck was trapped in a trail leading directly from one set of holes to another. This animal was caught some time before 7 A.M., and after dusk of the previous evening. The temperature averaged well below freezing during the night, and from six inches to a foot of snow covered the ground at the time.

On March 25, 1932, a "chuck" was seen on a snowbank about 5 P.M. Apparently the same individual was recorded an hour earlier by Harold Rightmyer. This same person saw a pair of "chucks" about 5:15 P.M., feeding some distance from their hole. They both entered the same den.

On March 27, 1931, I spent most of the day in the field. Conditions were ideal, with a temperature of 55° F. throughout most of the day, and little wind. A single "chuck" was observed. I passed through territory ideal for observing the woodchuck.

In all likelihood they run as much by night as they do by day during this period.

APRIL

"Chucks" appear on every hand with the coming of the first real warm spell, and show little choice of time for feeding or sunning themselves. They are more likely to be seen during the warmest part of the day.

On April 13, 1932, one animal was seen at dusk. On April 17, 1931, the whole day was spent in the field. The morning was cold, but toward noon it warmed, and the temperature averaged 50°-55° F. throughout most of the afternoon. One hundred and seven woodchucks were seen, and twenty collected. Few were seen before 9 A.M. About half were observed from 10 A.M. until 1 P.M., and the remainder were recorded, rather evenly distributed, from that hour until 5:30 P.M. After this, with a falling temperature, none were noted.

On April 23, 1932, a strong north wind accompanied by slight rains, falling harder at 6 P.M., did not keep "chucks" under cover. From this hour until dark, five were seen.

MAY

During this period "chucks" are still indiscriminate about their feeding periods. In 1931 and 1932, during May, the writer spent approximately one hundred hours in the field, and his companion, Harold Rightmyer, about half that amount. We kept exact notes on the time in the field, weather conditions, number of "chucks" seen, and the period of the day at which they were seen. About six hundred individuals were noted. They were observed equally as often in the morning as in the afternoon, except before storms, when they were much more active and ranged farther from their home burrow.

JUNE

Throughout this month vegetation is making rapid strides, and woodchucks are consequently harder to observe. Toward the latter part of the month, with the longest days of the year at hand, woodchucks were more frequently observed during the twilight hours.

JULY AND AUGUST

During this period it is commoner to see animals about the dens during the early evening than at other hours. However, the prolonged heat waves of July and August apparently affect this animal but little.

July 29, 1931, was extremely hot throughout the day. From 11 A.M. until 12 M. the thermometer registered 91° F. and the sun was very bright. Ten woodchucks were observed feeding during this period.

On August 4, 1931, I concealed myself, well before daylight, in some bushes commanding a good view of a four acre field, in which at least fifteen animals were known to occupy holes. At 5:10 A.M. the first "chuck" made its appearance, and by 6 A.M. another had shown itself. Neither attempted to feed, but sat about the entrance hole for a few minutes, and then disappeared. They could not have been alarmed at my presence, for what little wind there was blew toward me. These were the only "chucks" seen up to 8 A.M., when I left. I had previously seen as many as thirteen "chucks" in this field at one time in the early evening.

Again I secreted myself near a favorite feeding ground of these animals early one morning in August, long before darkness had departed. By 8 A.M. I had seen four animals, yet it was customary to see a score in this area over a two hour period in the late afternoon. However, during a three week period in June, 1932, when I had occasion to pass a strip of good territory between 5:30 and 6 A.M., I was usually rewarded with a sight of one or two animals about the entrance holes to their burrows.

A few hunters maintain that morning shooting is superior to that of the late afternoon. They even claim that more "chucks" are outside of their holes at this time. I cannot agree with these views, but further observations may possibly show them to be quite active at this time. Captive individuals (nine adults) were frequently observed feeding in their cages in the uncertain light that precedes daybreak.

SEPTEMBER

As with the preceding months, woodchucks are more active during the late afternoon than at other periods. On September 6, 1932, I was in the field from 1 P.M. until dark. Two animals were seen before 5 P.M. In the next hour and a half, eighteen were observed. On September 9, 1932, I was in territory abounding in woodchucks from 11 A.M. until 2:30 P.M. Three animals were recorded. The following day my companion and I saw six "chucks" between 3 P.M. and 5 P.M., and thirty-four animals between 5 P.M. and dark. We were in excellent territory for "chucks" during the entire period.

September 16, 1931, was very warm, the temperature reaching 85°

F. at 9 A.M. I watched a large individual sunning itself at noon on this date. The animal appeared dead. Its head was down, the hind legs were spread out, and the fur was blowing in the occasional breeze that fanned it. It made no move in over a half hour while I watched, until I attempted a closer approach, when it slipped into a hole near its snout.

On September 13, 1932, my wife and I closely scrutinized every favorable field for woodchucks from Cazenovia to Albany, N. Y., a distance of over a hundred miles, from 10 A.M. until 3 P.M. While we saw over two hundred sets of burrows, only three woodchucks were observed. The weather was ideal for their appearance.

During late September, woodchucks are becoming scarcer; some have commenced their winter sleep. On September 19, 1931, fifteen "chucks" were seen in a two hour period during the late afternoon. Several, while very much alive, were stretched out prone at the mouth of their burrows, as though dead. September 20, 1932, was a favorable day for their appearance. I saw no "chucks" from 4 P.M. until dark, but on the following day, at 6 A.M., a single individual was seen feeding. The animal remained out of the burrow for more than an hour. None were seen the evening of this day, in spite of excellent weather conditions.

September 27, 1931, was a cold raw day, with temperatures ranging from 52° to 56° F. Three woodchucks were seen in the morning by Harold Rightmyer, and he and I saw three more in the afternoon. Several hard frosts immediately preceded this period.

OCTOBER

On October 3, 1931, Harold Rightmyer collected six of twelve "chucks" he saw. He said they were taken pretty evenly from 9 A.M. to 3 P.M. He supposed that many had retired into their holes for the winter. The burrows that had previously been open and in use, now appeared to have been either deserted or filled with wind blown leaves and debris. This was a warm bright day, with temperatures ranging from 70° to 80° F. Five of the six taken were young of the year.

About a half mile from my home is a large alfalfa field, and in the midst of this land of plenty a woodchuck had made his home during the late summer. I had occasion to pass this field about 7:30 A.M. nearly every day, and sometimes several times a day, and can do no

better than to quote directly from my field notes the observations made on this individual.

"October 10, 1931. The 'chuck' in Marion's field was out at least twice today, once in the late morning and again about 5 P.M. Quite cool, wind strong and from the N. W.

"October 13, 1931. A heavy killing frost last night, with the temperature down to 26° F., yet at noon today I saw the 'chuck' in Marion's field. This same animal was out last evening at 5:30 P.M., while a cold wind was blowing.

"October 19, 1931. Again the 'chuck' is at the entrance to the hole at 7:30 A.M., the temperature is down to 28° F., and many previous nights have been as cold.

"October 23, 1931. At 7:30 A.M. I saw the 'chuck' sitting at the entrance to his burrow, and all about him the alfalfa is bent and white with a severe frost.

"October 26, 1931. The 'chuck' out at 1 P.M. Bright sun, no frost last night, but a cold west wind blowing."

This was the latest date the animal was seen. On Christmas, 1931, I excavated the hole, but found no woodchuck; likely he was safely ensconced in a dry cell off from one of the main shafts.

All the foregoing has to do with his feeding hours and sunning periods above ground. What are his habits in the darkened chamber and runways below the surface? Is it in sleep? To students of nature this may possibly be forever a closed chapter in the animal's life. I have tried to estimate this period spent in the burrow or nest.

Two entire days were spent in the field, one in July, another in August, during the season of 1931, watching a field of eleven sets of tenanted "chuck" burrows. Some of these animals were visible for three hours a day; others showed themselves for less than an hour. The period of activity above ground, in the course of a month, may be computed to be approximately ninety hours, with the assumption that a woodchuck stays daily outside the hole for three hours. From the first of April until the last of September, this would make a total of 540 hours. Many woodchucks still remain above ground in October, but they are in the minority. Allowing twenty-five hours as an average for this month and 100 hours for late February and March, we have a grand total of 665 hours. I believe this to be exceptionally high. There are 8760 hours in a year, so the period above ground occupies approximately 12½ per cent of the woodchuck's life. The rest is

spent in sleep or partial darkness. Certainly the woodchuck does not sleep twenty-one out of the twenty-four hours in the summer time. Yet he is below ground for that period. What he does during this period is an enigma that cannot readily be solved. There is yet much to be learned regarding the underground habits of all fossorial mammals. It is still a virgin field.

. HOME RANGE

A mass of data has been accumulated on the activities of woodchucks about their dens, and much thought given the subject, yet I am not at all certain what amount of ground an average woodchuck will claim as its territorial right. It is not an uncommon sight to see two or three feeding woodchucks within a few feet of one another. One animal may have its home den within a yard or two of its feeding position, while another may have travelled two hundred yards to reach suitable feeding grounds.

In considering the home range, I do not include the early spring *wanderlust* of woodchucks, impelled by the mating urge to wander far in search of a mate. We are concerned here with the normal activities of these animals, from May to early fall.

On April 17, 1931, nearly one hundred woodchucks were seen. Some were one hundred yards from the home den, by actual measurement, and when alarmed passed by several nearby dens to reach their own. When a frightened woodchuck goes into the most convenient hole, and another animal is occupying it, he will quickly be driven out by the rightful tenant, and sent scurrying to his own retreat. Several times during this day of observation woodchucks were alarmed, and put into the wrong hole. They were apparently quickly ousted, and in one instance a "chuck" was pursued by a smaller individual, that chased it into its rightful burrow.

On May 5, 1932, a "chuck" was seen to enter three widely separated sets of holes, during the course of half an hour. It travelled 270 yards in this time, and fed intermittently. This area had a sparse woodchuck population. It is evident, that a woodchuck in a community where these animals are not overly abundant, will make several series of holes and utilize each set, possibly on alternate days, as its mood dictates.

During the same day several animals were seen at least one hundred yards from their dens. On May 6, 1932, twelve animals were

collected. These were ranging, for the most part, from fifty to one hundred yards from the den. It was just before a rain.

Woodchucks will make considerable journeys for suitable feeding grounds, as recorded by Robinson, under the discussion of swimming. During August of 1932 I frequently visited a large field of three acres covered thickly with red clover and plantain. Almost any evening from six to ten animals could be seen in this field. From a convenient knoll, used as a vantage point, the animals could be seen hurrying from an old orchard, where they lived, to feed on the green plants of the larger field. Well worn trails through the orchard into the stand of clover were over two hundred yards in length but usually somewhat shorter in distance.

Dr. George M. Sutton, in company with some friends, saw an interesting spectacle regarding the endeavors of a woodchuck that had wandered far from home in search of better pastures. On April 19, 1931, this observer, while studying birds at Taughannock Falls, near Ithaca, N. Y., saw a "chuck" on a narrow ledge, precariously making its way along. A sheer drop of one hundred feet or more separated the ledge from the bottom of the gorge at this point. Finally it reached a talus slope, down which it plunged, and made its way to some blossoms of the coltsfoot, *Tussilago Farfara*, upon which it immediately commenced to feed. It would take a blossom in its mouth, eat it, then sit upon its haunches and look about for some time, when it would commence feeding again. It consumed many blossoms, and was observed for a long period, until the watchers finally tired and departed. Whether the "chuck" located these flowers by accident or design it is difficult to say. At any rate, the observation shows an indomitable will and a fearlessness not to be denied, nor matched, when hunger assails this creature. No hole was seen, but suitable cover for burrows was within a hundred yards.

From the above rather random observations, we may safely conclude, without gainsay, that "chucks" commonly travel a hundred yards from the den and may go an eighth of a mile when suitable food plants are not readily available.

SANITATION

The groundhog is a cleanly animal and meticulous about its toilet. The feces are deposited in a dry cell a few inches off from the main shaft of the burrow or in a terminal pocket of one of the long galleries.

More often they are buried in the mound at the entrance. I have frequently seen the animals dig a little hole, deposit the feces, and then carefully cover the hole, usually with the fore paws, but never with the nose. But Godman (1826) says:

"There is no animal so perfectly cleanly in its habits as this marmot. However numerous they may be in any vicinity, their excrement is not seen, nor any offensive odor perceived. Whenever the calls of nature are felt, this animal seeks a spot at some distance from his dwelling, and having dug a hole of two or three inches in depth, and performed his evacuations, he covers it up with extreme care; and not content with placing a thick layer of earth over it, he presses or rather rams it down with the end of his nose, striking it with a force which seems extraordinary when thus applied."

It has been my experience, through many long hours of watching, that the woodchuck never defecates away from the den or entrance to it. All the droppings are finally buried in the mound. Frequently one finds five or six little spaces, freshly dug and worked over, which, upon being uncovered, reveal several recent depositions of feces. At times these holes are left uncovered for some time.

The young "chucks," when in the nest, deposit their feces in the nest chamber. The female covers this waste matter by continued applications of new bedding, directly over that of the old. When enough has been accumulated to make the nest unsanitary, or too bulky, the entire lot is removed, and fresh material added. Such is the case with captive animals, when furnished at all times with an abundance of food, water and plenty of nest material.

In the wild state, when the young are two or three weeks old, and some time prior to their appearance above ground, the old animal frequently cleans house; that is, she throws out damp grass matted and soaked with fecal waste. How often this is done I could not determine.

REPRODUCTION

GESTATION PERIOD

Unfortunately the writer's animals have been for the most part specimens caught wild which would not mate readily in captivity. Attempts to induce the mating act in such wild specimens were without avail. However, a female collected with a male on March 22, 1931, gave birth to five young on April 7. Thus she carried them

seventeen days while confined. A large female taken on March 28, 1932, had five young on April 15. This would make the period at least seventeen days.

In all likelihood the gestation period is not over a month's time. It is certain that the animals mate in the field. This has been substantiated by field observation.

A female trapped on April 17, 1931, was so injured that she was killed. This animal contained five 60 mm. embryos all in the left horn of the uterus. I had this animal, a very dark individual, under observation for some time previously. On March 22, twenty-six days before, this same animal was noted with a much lighter colored animal, ostensibly a male, which was seen to make overtures to her. I think the mating act may have been consummated at this time. Inasmuch as the young were within a day or two of birth, this would fix the gestation period tentatively at four weeks.

Mr. William Mosher, of Perry City, N. Y., who has bred these animals and raised a number of litters, informs me the period is just four weeks.

If we turn to the evidence of analogy, we find the ground squirrels of the west have a period averaging about twenty-eight days. Shaw (1925) has found the period to be twenty-four days in the Columbian ground squirrel (*C. columbianus*), while in the thirteen-striped ground squirrel (*C. tridecemlineatus*) a much smaller form, Wade (1927) found the period to be twenty-seven days. Edge (1931) thinks the period for *Otospermophilus douglassi* to be from twenty-five to thirty days. Writing on the White-tailed prairie dog (*Cynomys leucurus*), Stockard (1929) places the period between twenty-seven and thirty-three days. The woodchuck is not far removed from these animals, and we might logically expect, because of the spring habits these animals have in common, that the gestation period of the eastern *Marmota* might approximate that of its western relatives.

FEMALE DURING PREGNANCY

The substantial layer of fat acquired during the previous fall aids the female in great measure the following spring. Her advent is frequently marked by heavy snows, frozen ground and the necessity of using bark for food. This reserve food, stored as fat, is indispensable at this period, for, paradoxically enough, woodchucks commonly retire for the winter sleep in a land of plenty, and emerge from this

long slumber weeks before the first green plants are in evidence. Little is eaten for the simple reason that there is nothing to eat.

At this time the bark of wild cherry, sumach, apple, occasionally hickory and perhaps some other barks are consumed, but at best it is a long fast. "Chucks" probably eat little for a few days preceding parturition, if the habits of captive individuals are any criteria of wild animals. Caged animals have a tendency to become restless a day or two before the young are born, and frequently take food into the nest or tunnel. Probably this habit is not restricted to captive individuals, for on April 19, 1932, when a large burrow was excavated, small pieces of green sod, grasses, and clover, showing evidence of having been fed upon recently, were encountered well within the burrow. The female trapped from this burrow had well advanced embryos, within a day or two of birth.

NUMBER OF YOUNG

The average number of young is 4.07. This figure is derived from embryo counts in thirty-one gravid females, in addition to counts of the uterine placental scars of eighteen woodchucks recently past parturition. Field observations on families of young, bear out the number arrived at by foetal counts, and show that prenatal counting does not give a higher percentage than is to be expected. The average number of a score of families under observation during the spring of 1923, 1927, 1931, and 1932, is slightly greater than four (4.3).

Not infrequently foetal atrophy reduces the original number of embryos. Four instances were encountered in making foetal counts. Occasionally one finds an embryo less developed in size than the normal ones. These may, in some instances, be born dead. Probably many live a number of weeks, but, handicapped as they are, in all likelihood, they eventually succumb. In the spring of 1932 I had a captive female give birth to five young. Of these one was noticeably smaller than the others, and differed remarkably in coloration. In general, its coat color was a uniform ochraceous-orange. This individual lived for thirty-two days, but became constantly weaker after it had reached the third week.

Several times, when an entire family in the field has been collected, one young was found to be considerably smaller than the others, and proportionately less developed.

That they do not all have the same physical endowments at birth,

is shown by a litter of three young born on April 28, 1932. One weighed thirty-nine grams, another thirty-three grams, while the runt weighed twenty-four grams. Obviously this young one, even though of a small litter, would be greatly handicapped.

TIME OF BIRTH

The earliest actual date of birth I have recorded is the case in which a captive female bore young on April 7, seventeen days after she was captured. These were perfectly normal, and well developed in every way. Another, collected on the same date, had 60 mm. embryos. Obviously, these were within a day or two of birth, for embryos 60-68 mm. were practically as well developed and as large as new born young.

On April 11, 1931, a female was collected with five 62 mm. embryos. These likewise were ready for birth. On April 18, two nursing "chucks" were shot.

As late as May 1, 1931, an animal with two 18 mm. embryos was shot. These were assumed to be about four-fifths developed, and would have been born within the week.

Thus the young are born in central New York from the first week of April until the middle of May, over a period of five or even six weeks.* Probably some young are born in late March, for our record of thirty-one sets of embryos is in no ways a complete study. From these observations, however, one might reasonably infer that six weeks would cover the period over which the young are brought forth. We should hardly expect to find such a prolonged period for the presentation of the young if the animals had mated the previous fall. Bats, some mustelids, and bears, usually have young, in their respective groups, within a few days of one another. Especially is this true of bats, in a large colony, when the young are born over a period of a very few days. It is common knowledge that these groups mate the year preceding the birth of the young, nearly twelve months elapsing in the case of the fisher.

Possibly woodchucks have several œstrual cycles in the spring, at which times the males serve the females, if available. It is of interest

*Mr. Owen Beckwith of McLean, N. Y., collected a large gravid woodchuck on May 26, 1933. Beckwith stated that the animal contained four large embryos, about the size "of my thumb." These were, in all probability, within a day or two of birth, and constitutes the latest record of a pregnant female I have encountered.

to note that the larger, older animals mate the earliest, consequently the young first seen with the parent are those conceived during late February or early March. Some very small females were carrying young in early May.

The following table, showing the records of embryos taken from gravid females during the spring of 1931 and 1932, is designed to show the relative development of the embryos throughout the spring. In a few instances, where placental scars are visible, are included records that indicate the number of young. All measurements from the crown to rump are expressed in millimeters, and were made with dividers.

DEVELOPMENT OF EMBRYOS

DATE	NUMBER	POSITION	SIZE
March 31, 1932	4	3 left, 1 right	3 mm.
April 1, 1931	4	2 left, 2 right	23 mm.
April 5, 1931	6	6 right	11 mm.
April 7, 1932	4	2 left, 2 right	60 mm.
April 7, 1932	5	Young born in captivity
April 11, 1931	5	5 left	61 mm.
April 11, 1931	5	1 left, 4 right	35 mm.
April 14, 1932	3	2 left, 1 right	32 mm.
April 12, 1931	6	1 left, 5 right	13 mm.
April 15, 1931	5	Young born in captivity
April 16, 1931	4	2 left, 2 right	40 mm.
April 17, 1931	5	5 left	55 mm.
April 17, 1931	3	2 left, 1 right	62 mm.
April 17, 1931	5	2 left, 3 right	26 mm.
April 17, 1931	2	1 left, 1 right	18 mm.
April 17, 1931	4	2 left, 2 right	15 mm.
April 17, 1932	3	3 right	35 mm.
April 18, 1931	4	3 left, 1 right	Just born
April 18, 1931	4	1 left, 3 right	33 mm.
April 18, 1931	5	2 left, 3 right	Recent parturition
April 21, 1932	5	2 left, 3 right	34 mm.
April 21, 1932	3	2 left, 1 right	14 mm.
April 21, 1932	4	Young born in captivity
April 21, 1932	4	Young born in captivity
April 23, 1932	4	4 right	Recent parturition
April 24, 1931	4	3 left, 1 right	Recent parturition
April 30, 1932	4	2 left, 2 right	24 mm.
May 1, 1932	2	1 left, 1 right	18 mm.
May 2, 1932	5	4 left, 1 right	Recent parturition
May 4, 1932	2	1 left, 1 right	68 mm.

DESCRIPTION OF YOUNG

The following notes are based on observations made on seven litters of new born young, comprising thirty-one individuals. Three of these litters were successfully raised by the parent until they were weaned.

YOUNG AT BIRTH

The young, as with various species of ground squirrels at birth, are blind, naked and quite helpless. In general, directly after birth, the color is dark pink; it is flesh color twelve hours after birth. The only hairs are five small ones directly over the eye, measuring 2 mm. in length, together with five somewhat shorter genal hairs on each cheek. The external auditory meatus is closed, while the eyes appear merely as a darkened area on the face. The fore limbs are, of course, much better developed than the hind limbs. The young animals are quite active but their movements are not coordinated. One individual remained active, when removed from the parent, for thirty-two hours, when it was killed. At birth a sucking note is readily heard from a distance of several feet. (Plate XV, fig. 1)

The average measurements of eight new-born young, four males and four females, are as follows: total length, 105 mm., tail, 16 mm., hind foot, 13 mm.

There is no apparent correlation between the weight of the litter and the number of young comprising it. The following table bears this out.

WEIGHT OF YOUNG AT BIRTH

NUMBER OF YOUNG IN LITTER	WEIGHT OF LITTER IN GRAMS	WEIGHT OF INDIVIDUAL
5	140	28, 28, 26, 25, 35
3	96	39, 33, 24
3	78.5	28.5, 26, 24
5	124	29, 25, 25, 23, 22
4	113	33, 28, 28, 24

The average weights of twenty individuals from birth to twelve hours after birth averaged 26.5 grams.

ONE WEEK OLD

The head and back is heavily pigmented. The snout and forehead have short grayish fur, darker on the forehead, while the rest of the body is without visible hair. The genal vibrissæ are especially prominent, while the mouth is very large. The fore claws are black at their base. The fore limbs are still noticeably stronger and larger than the hind ones. The remnant of the umbilical cord has completely disappeared but the scar remains. In general, the dorsum is sooty gray, but the belly remains flesh-colored. (Plate XV, fig. 2)

The average measurements of eleven are: total length, 120 mm.; tail, 22 mm.; hind foot, 16 mm. The average weight of nine individuals was 52 grams.

TWO WEEKS OLD

The fur of the snout has become grizzled gray, almost approaching white, being the longest hair on the body except that of the vibrissæ. The chin and upper throat are colored like the snout. Head with short black fur, back of neck and fore part of dorsum above shoulders a light brown, the rest of the body with short dark brown fur, almost approaching black in places. The fore claws are jet black. The hair of the outer side of the fore limbs, in the region of the elbow, are now the longest on the body. The genal vibrissæ are quite long, as are those of the upper lips, while the gular vibrissæ have made their appearance. These latter sensory whiskers measure 6-8 mm. in length.

The average measurements for seven are: total length, 150 mm.; tail, 35 mm.; hind foot, 26 mm. (Plate XV, fig. 3)

Nine specimens have an average weight of 80.5 grams.

THREE WEEKS OLD

The head is black, excepting the snout, which is still with a grayish cast. This is being rapidly effaced by the appearance of black hairs about the nose. The lower fore limbs remain black, as do the nails, while the upper arm has taken on a decidedly reddish brown luster. The tail is better furred at the distal than at the proximal portion, as is the condition in adults. A pronounced sucking note is evident most of the time at this age, except when the animals are sleeping. The

young can crawl about readily, but are incapable of supporting the body above the substratum. (Plate XVI, fig. 1)

The average measurements of seven are: total length, 191 mm.; tail, 36 mm.; hind foot, 32 mm. The average weight of these individuals was 130 grams.

FOUR WEEKS OLD

Eyes are opened. One young opened an eye at twenty-six days, another opened a single eye on the twenty-seventh day, while all had both eyes opened on the twenty-eighth day. An apparent effort on the part of the animals to open their eyes, a day or two before this event actually took place, was noted. Much twitching of the lids preceded the actual opening. When first opened, the eyes appear to have a thin blue film over them. This disappears within from twelve to twenty-four hours and the bright handsome eye is present. With the opening of the eyes, the entire life of the animal undergoes a change. The young commence to feed upon green matter, and venture hesitantly from the nest box or tunnel. (Plate XVI, fig. 2)

At this stage, the top of the head, between the eyes, the fore and hind legs, are black, while the rest of the body is a grizzled grayish brown, with an indistinct gray saddle. The sparsely furred belly has a rusty cast. An individual preserved at this age had both milk and green matter in the digestive tract. The tongue is enormous in young woodchucks. A specimen, four weeks old, had a tongue twenty-six millimeters in width. This necessitated curling on the sides to fit in the smaller mouth cavity.

The young probably leave the den for the first time with the opening of the eyes. The lower incisors have erupted, and the milk teeth between them appear ready to be lost. The upper incisors have not broken through the gums, although they appear as small white knobs.

The average weight of seven animals was 188 grams.

FIVE WEEKS OLD

The young now have the typical coloring of the unshed adults. The small animals are not fuzzy, but are sleek little fellows. The upper incisors are just erupting. The babies are now able to emulate the adults in voice, for when handled they grate together the cheek teeth,

making that noise so common to adults. The whistle of alarm is frequently heard from these precocious individuals. Several of the young are still attempting to nurse. (Plate XVI, fig. 3)

The average measurements of seven are: total length, 260 mm.; tail, 55 mm.; hind foot, 47 mm. The average weight of these is 247 grams.

From this period on, all young "chucks" have emerged from the burrow, and are romping and playing about while not engaged in feeding. Their growth is rapidly accelerated with the weaning period past, and a varied diet of succulent young plants to tempt them. Captive young, at seven and one half weeks, weigh a pound, while wild individuals, estimated to be not more than eight weeks, are a pound and a quarter. At seven weeks captive individuals average, in measurements, as follows: total length, 292 mm.; tail, 63 mm.; hind foot, 54 mm.

As the care of the young at this age took more time than I had at my disposal, all were liberated when eight weeks old after being marked to identify them readily if recaptured.

THE NURSING PERIOD

Directly after giving birth, the female normally eats but little. A captive that had five young during April, 1931, did not feed for three days following parturition, although a generous supply of greens was supplied daily. A "chuck" that had young on April 7, 1932, fasted until the afternoon of the 10th. A captive that had young on April 21, 1932, commenced to feed about twenty-four hours after delivery. It might be inferred from these brief observations that females with young born early in the season do not require food for some time after the young are brought forth, as their storehouse of fat allows for sustenance both for them and their young. It is obvious that there is a paucity of food during these early days of spring. With the coming of dandelions, grasses, and the earliest clover, food is more readily obtained, and the reservoir of fat has quite disappeared.

As the young develop and approach the fourth week, the mother customarily takes food into the tunnel or nest chamber in anticipation of the weaning period, now close at hand.

The eight teats—two pairs, thoracic; one pair, post-abdominal; and one pair, inguinal—are equally used. All are swollen and produce a good flow of milk. The first to become dry is the anterior thoracic pair. (Plate XX, fig. 3)

In the act of nursing, it seems not unlikely that the female will stand upon her four feet rather than lay on her side, as do rats, mice, and most small quadrupeds. Repeated observations of suckling young have illustrated this thought. It may be that the intrusion of an observer has driven the nursing animal to this position, but great care has been exercised in observing the nest life of the animals, so that a minimum of noise has been made to disturb their otherwise normal actions.

When the young first leave the nest, they are still nursing. Frequently they will grasp a thoracic teat and commence to feed when the female is in an upright position. Occasionally they will be rebuffed by a sharp blow of the fore paw, especially if they become overzealous in their endeavors and hurt the mother. Apparently she suffers some discomfort when the young are nursing in this manner for she appears uneasy and ill at ease after a few moments of such treatment. The nipple may be long drawn out after the endeavors of the young. They also feed from the abdominal and inguinal teats when the female is in a standing posture, but this is not as frequently observed as the other. Writing of *Marmota caligata*, Harmon (1822) says, "they generally produce 2 young at a time, and set upon the hind feet when they give them suck."

It sometimes happens that the venturesome young ones, straying from their nest when they have first appeared, become exhausted from their efforts, and lay motionless. The mother then carries them back to the nest, lifting them either by the loose skin of the back of the neck or over the shoulders.

DEVELOPMENT OF YOUNG THROUGH THE FIRST SUMMER AND FALL

In the spring of 1931, the first young woodchucks were seen outside the den on May 19. These were feeding within a few feet of the entrance, while the mother travelled about one hundred and fifty feet from them in search of food. On May 22, 1931, a young male was collected. It had the following measurements: total length, $14\frac{1}{2}$; tail, $3\frac{1}{2}$; hind foot, $2\frac{3}{8}$. It weighed 1 lb., 6 oz., and was estimated as eight weeks old, on the basis of weights and measurements of captive individuals. This animal must have been born late in March.

From May 19 to 29, 1931 and 1932, twelve young "chucks" were secured. These average 1 lb., 3 oz., and the average measurements are: total length, $14\frac{1}{2}$; tail, $3\frac{1}{2}$; hind foot, $2\frac{1}{2}$.

During June of 1923, 1931, and 1932, nineteen young were collected. These average 2 lbs., 1 oz., and the measurements for these average: total length, $16\frac{1}{8}$; tail, $4\frac{3}{8}$; hind foot, $2\frac{5}{8}$.

Young shot in July of 1931 and 1932 number twenty. These average 3 lbs., 4 oz., and average: total length, 20; tail, 5; hind foot, 3.

August young, over a two year period, total twenty-six individuals. These average just 4 lbs. and the measurements are: total length, $20\frac{1}{8}$; tail, $4\frac{3}{4}$; hind foot, 3.

Measurements of twenty-eight young collected over a two year period in September give an average weight of 5 lbs., 13 oz. (4-4, 7-8). Males are somewhat smaller than females, for the latter average 6 lbs., 4 oz., for thirteen individuals, while fifteen males average 5 lbs., 6 oz.

The measurements of these twenty-eight young average as follows: total length, $20\frac{4}{8}$; tail, $4\frac{1}{2}$; hind foot, 3. Thus we have an increase in body length of nearly an inch, in spite of the fact that tails of August specimens average somewhat longer than those of animals taken a month later.

It frequently happens, in studying specimens collected in September and October, that little or no immediate difference can be detected, externally, among large young of the year and adults. For a study of growth, it is highly desirable to fix the age of these individuals, in order to determine correctly the rate of growth and seasonal development of the young. Weights and body measurements are of some aid, but the real indices are found in the skull and in certain bones of the skeleton.

Young animals can usually be determined at a glance until the first of August, when they commence to approximate in size the subadults or small animals of the previous year. The following table is designed to bring out certain salient facts regarding the discrimination of young from old animals.

Some of the characters listed below under "less than a year old" may be found in these same individuals in the following spring. At that season, however, there is no danger of any confusion, for all are a year old, or more. The fusion of bones, loss of sutures, and ossifications of the epiphysis, are all accomplished in these animals before the young of the year have grown sufficiently to warrant any critical analysis, in order to separate the two groups.

CRITERIA FOR DETERMINING AGE GROUPS OF WOODCHUCKS

LESS THAN 1 YEAR OLD.	MORE THAN 1 YEAR OLD
Median occipital keel wanting, or if present very weak.	Median occipital keel usually strong.
Distinct suture separating frontal and parietal elements dorsally.	Frontal and parietal elements fused dorsally.
Occipito-nasal length under 84 mm.	Occipito-nasal length usually over 86 mm.
Pm. 1 and 2 in upper jaw and pm. 1 in lower jaw of milk dentition present.	Permanent dentition present.
Well marked sutures separating three principal elements of innominate bone.	Elements of innominate bone fused. No sutures visible.
Epiphyses of radius, ulna and humerus incompletely ossified. Ulna not exceeding 65 mm.	Epiphyses of radius, ulna and humerus strongly ossified. Ulna exceeding 70 mm.

As has previously been stated, this table has its greatest usefulness in determining large young collected in September, and small adults taken during the same time. External measurements are apt to give faulty interpretations as to the correct age of the animal under consideration.

October young are represented by four individuals. These average just an even 6 lbs. A $3\frac{3}{4}$ lb. individual, taken on October 3, 1931, has not been included. This was a poor animal, had not molted and was otherwise in a sorry condition. The measurements of these four average: total length, $21\frac{1}{2}$; tail, $5\frac{1}{2}$; hind foot, $3\frac{1}{8}$.

RELATION OF THE FATHER TO THE FAMILY

Seton (1909) has said that some woodchuck fathers actually seem to stay, or to return home, and that they divide with the mother the care of the young.

I am inclined to agree in this statement, most certainly so in some instances.

A captive female, caged with a male in the spring of 1932, gave birth to five young. At the time of parturition the male was present in the nest chamber and remained with her until about twelve hours

later, when he was removed. The young were successfully reared. At no time during pregnancy did I see the female assume a belligerent attitude toward her consort. He appeared to be accepted as a matter of course. It is obvious that such an observation has little value toward an understanding of the conjugal felicity of these rodents, captive as they were. But the following records from the field offer substantial evidence that the male remains with the family, or is normally very close.

On May 26, 1931, a female with three young was observed feeding. The female and one young were collected. An hour later an adult "chuck" was seen at the entrance to this hole wagging its tail from side to side. It is assumed that this was a male.

During the late afternoon of June 6, 1932, two old "chucks" and four young were seen feeding together. They all scrambled into the same hole when alarmed.

On the same date, a large individual was shot at, but escaped unscathed. In its haste to get off, it ran into the nearest hole at hand, a burrow occupied by a large female and her young. It soon scurried out and made off to another system of burrows, some one hundred and fifty feet away. Possibly this indicates that all woodchucks do not tolerate the presence of their kind during the period when they have young. Further studies on this factor in the animal's life are desirable.

RIVALRY AMONG MALES

Woodchucks commonly fight among themselves during the early spring. That these vernal combats are usual among the males alone, perhaps over a prospective mate or a bit of choice territory, is not so readily determined.

From my notes of April 7, 1923, the following is extracted. "While fishing today along a small stream west of Trumansburg, N. Y., I approached quite close to two "chucks" engaged in noisy combat. The larger had a grip on the other's ear, while this unfortunate smaller individual squealed unlike any "chuck" I have ever heard. In attempting to approach closer, the better to witness the fray, I was seen, and the smaller quickly tore itself loose and "denned" in a nearby hole. The larger appeared quite unconcerned over my presence, and remained in the field for some time."

On April 15, 1931, several males were collected that showed un-

mistakable signs of recent vicious encounters. One was minus an ear, the wound quite fresh, while several had deep gashes on the head and forelegs. A few taken throughout April have had large, freshly healed scars on the forehead.

A subadult male shot on May 21, 1931, had a large scar on the chest and right foreleg. These wounds were healed over but contained a quantity of pus. A large male lived within seventy-five yards of this individual and a litter of young were secured within one hundred yards of the wounded animal's quarters.

The females do not always escape from battle. A lactating female collected on May 1, 1931, had a prominent, raised scar on the forehead, between the eyes. Of course it is possible this may have been the result of a bullet the previous year. A smaller, freshly healed "bite" was certainly an episode of but a few weeks previous.

On May 27, 1931, a female was easily overtaken in the field. When it attempted to run it fell on its side repeatedly. Examination revealed a large scar on the shoulder, the size of one's thumb. A large festering sore, as large as a golf ball, on the animal's felt flank, may have been due to a bullet, but quite possibly the result of a fight.

On April 6, 1932, a small male was taken which had a severe gash on the right foreleg and an ear missing. Three "chucks" in all have been collected at one time or another that have had an ear missing. One individual had lost both. Frequently the distal part of the tail is absent, and a bob-tailed male was collected in the spring of 1923 near McLean, N. Y.

AGE OF SEXUAL MATURITY

While woodchucks do not commonly complete their growth until late in the second year, they frequently breed as subadult, when one year old. Positive proof of this is furnished by marked individuals.

During the early summer of 1931 a number of young animals were trapped, and when not too badly injured, were marked and liberated. Marking was accomplished by punching or clipping an ear and excising a toe. Of eleven individuals so marked, only two, both females, were recovered the following spring. One, taken March 29, 1932, weighed three pounds, six ounces, but contained four embryos. Another marked individual, taken a week later by Mr. Edward Drake, carried no young but might have bred later in the season, had it been allowed to live.

Not only do the subadults have fewer young, but they frequently

go unmated the first year. In 1931, I collected thirty-nine females during the breeding season, assuming this to be from mid-March to mid-May. Of this number, twenty-one were subadults, or commencing their second year. Fifteen had not bred while six were carrying young. Of eighteen adult females, seventeen had mated while only one had failed to breed.

In 1932, over the same period, a late spring and much snow kept woodchucks under cover so that fewer were secured early in April. But of twenty-six adult females, all had bred, while seventeen of twenty-two young females had not conceived.

Thus we find, over two breeding seasons, only one of forty-four adults had failed to breed, while of forty-three subadults taken during this period, all but eleven were virgins.

We cannot attribute this larger number of unbred females to lack of males, for they are as numerous as the females. In tabulating the sex of all the woodchucks taken, we find the males to outnumber the females in the ratio 114-100. This count, or ratio, may be fortuitous, but further studies will probably prove it to be rather accurate. The males of white rats outnumber females. It is likewise so of man.

Of eighty-three males taken from March 15 to May 15, 1931 and 1932, forty-five proved to be subadults. Of these, fifteen had enlarged testes, but only four individuals had them descended into the scrotum. These were animals collected early in May. Perhaps the young males do their share of the breeding as the season advances. Only four of the thirty-eight adult males did not have enlarged testes. The remainder had gonads that were swollen and descended.

It is difficult to determine to what size the testes must enlarge before they are functional. An arbitrary length of twenty millimeters was decided upon to separate supposedly breeding animals from those not breeding. Descended testes always measured more than this; smaller subadults never have testes as large.

Measurements, in millimeters, of descended testes in fully adult males, give random figures as follows: 24 by 15, 26 by 14, 27 by 13, 30 by 17, 20 by 12 and 30 by 18. The average weight of six pairs of descended testes was 7.6 grams. Among subadults, similar measurements are: 15 by 6, 16 by 9, 14 by 5, and 15 by 9.

All through the summer specimens are occasionally collected which have enlarged testes. These gonads never assume the proportions of those in individuals collected in the spring.

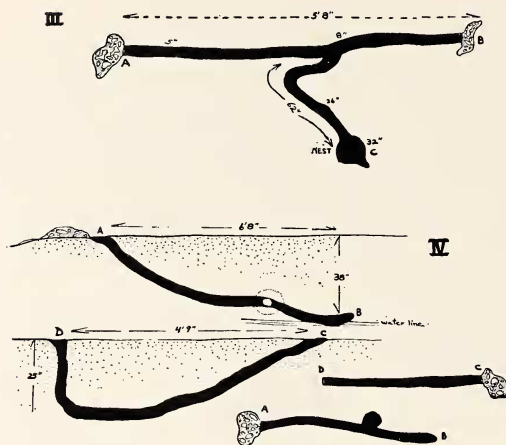


FIG. III. Hibernating den of Woodchuck.

FIG. IV. Adjoining Woodchuck burrows. The two figures to the left are side views, the figures to the right show their relative position to one another. The pocket in the tunnel A-B had a large accumulation of feces.

seldom passes a week without fresh material being added. Good criteria of the woodchuck's presence are foraging trails, leading from one burrow to another, and striking at every angle from the main shaft into the surrounding fields.

There are usually two entrances, sometimes three, rarely four or even five.

The shaft from the main hole (that with the most prominent mound) slopes at varying angles. Young animals of the year, when first commencing the strenuous task of making homes for themselves, commonly have only one entrance, and this is usually of a shallow nature. Older animals strike deeper, and the tunnel may pass at an abrupt angle for almost a foot, before the incline grades off.

In general, woodchucks have wide entrance holes that narrow very abruptly a few inches after leaving the surface. Holes that may have a diameter of twelve inches at the entrance have a bore of only four inches when a foot of earth has been excavated.

Usually the woodchuck makes some provision for a spring freshet or high water by having the lowest part of the shaft midway between the entrance and the nest chamber. When the nest is at the lowest part, as sometimes happens, immediately behind it and away from the entrance, a short blind pocket may be found, leading up and away

from the nest. That the animals do not always plan wisely or choose well, in selecting a site for a burrow, is evident from the following observation. On April 12, 1931, in company with Mr. Robert Rightmyer, the writer saw a woodchuck disappear into a hole on the summit of a rather extensive ridge, composed for the most part of heavy clay soil. We looked in the hole and could see the animal, immersed in water to its neck. The site was not an appropriate place for a burrow, as standing water had all but flooded the occupant out. On seeing us, the animal pulled under the water, but could not remain in such a situation long, and was easily dispatched.

There appears to be no consistency as to the width or height of the burrow throughout its course. Part of the burrow has a diameter just sufficient for the animal to squeeze through. In stony soil, protruding stones sometimes block the passage so as to make any real speed difficult in the underground runway. Again, the tunnel may widen to permit of easy turning for the animal.

At the entrance there is usually a somewhat widened area. This is

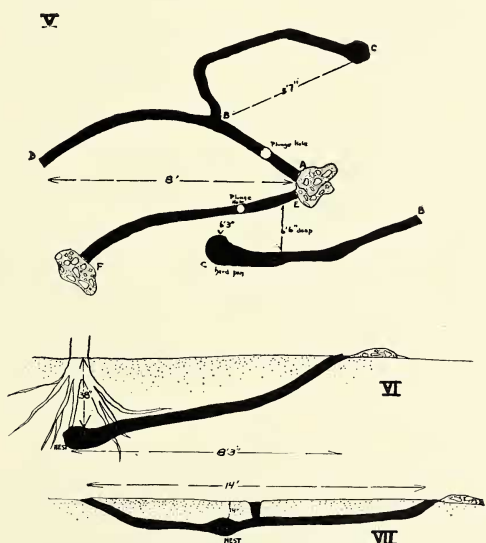


FIG. V. A large Woodchuck burrow. B-C is represented in side view in lower part of drawing.

FIG. VI. Hibernating den of Woodchuck.

FIG. VII. Hibernating den of Woodchuck. A large female was taken from the nest.

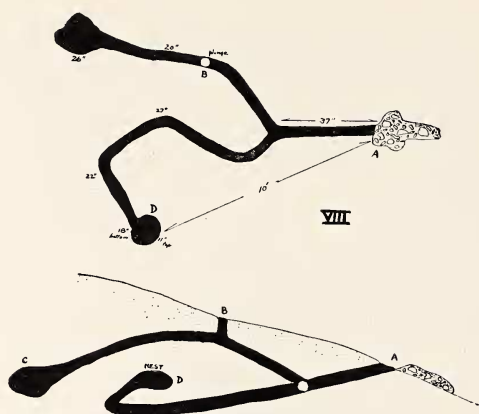


FIG. VIII. A long established Woodchuck burrow. Upper figure is view from above, the lower a side view. A Woodchuck hibernated in the nest at D.

resorted to when the animal runs in the hole and immediately appears again at the entrance, turned about. Again, in many instances, but more especially in burrows long established and occupied by old animals, there is a simple platform (Plate XVIII, fig. 3), an inch or so below the general surface. The woodchuck will rest the forepart of its body on this area, while surveying its domain. The diameter of the entrance hole in one hundred burrows, measured three inches from its inception, averages 6.7 inches in height and seven inches in width. In seventy instances it was slightly less than this, the remainder being larger. In general, the size of the inhabitant can be roughly judged from the size of the hole. The largest hole measured was twelve by fourteen inches and housed an $11\frac{3}{4}$ pound "chuck." Holes in hedgerows are larger than those in the open field, perhaps because they have been longer established and because they have protected a greater number of animals, including skunks and rabbits.

The plunge hole has a diameter which is considerably smaller than that of the other holes. It is never larger than is necessary to admit the animal's entrance. They frequently measure four by four or four by five inches.

The size of the hole is directly dependent on the type of soil the woodchuck has chosen for the burrow. The depth of the burrow is likewise fixed by the texture of the soil. In sandy situations, woodchucks will dig to a depth of six feet, while in gravelly soil, composed of

many large stones, the depth is rarely greater than four feet, and frequently not that.

The angles of entrance are less marked on level ground than in burrows situated on a pronounced slope. The angles on a slope strike deeper, and are considerably more abrupt.

The speed at which excavating is done is amazing. A woodchuck can bury itself from view in a minute, providing the soil is reasonably light and porous. Simple burrows with a single entrance, totaling five feet in length, are completed in a day. Three such instances, recorded in August, 1932, show burrows probably made by young animals doing their first digging, to average five feet in length, but of rather a shallow nature. These were all made in a single day. It is even possible that they were the work of one animal, as they were all within a hundred yards of one another. It seems more likely that a family, recently broken up, had been jointly responsible for the fresh burrows.

The deepest burrow I have unearthed in central New York went to a depth of seventy-six inches, or well over a tall man's head. Others that have been opened have penetrated to a depth of five feet rather frequently, but usually the nest chamber is located within two feet of the surface, and not infrequently little more than a foot.

From the main shaft one encounters blind pockets. In these may be found fecal remains, partially covered by dirt. At other times they form a hard dry cell, perhaps a foot from the principal tunnel. It is not unlikely that these have served as hibernating cells. All the burrows opened in seasons other than winter have had these chambers. Winter excavations have failed to produce such cells. It is not beyond reason to suspect their presence, but being plugged tightly, they could not be detected. Inside these were possibly dormant animals, safely ensconced for the long sleep of winter.

NESTS

The nests are usually rather small for such a large animal. They seldom measure more than fifteen inches in diameter and half as high. They are constructed from the nearest available material. In woods, the fallen leaves of deciduous trees are used, while in fields studded with goldenrod and asters, the dead leaves of these plants are utilized. A combination of dead leaves and dry grasses often makes up the sleeping quarters, but more frequently the nest is constructed wholly of grass. About one third of the excavations revealed no nests, simply

an enlarged chamber at the furthestmost recess, yet such burrows were known to be tenanted. (Plate XIX, fig. 3)

TRAILS

Leading from all occupied burrows are well defined trails. These are especially prominent in late spring and summer, and again after the hay is cut. When the grass is high it conceals these trails, arching over them, so that frequently, when the runway passes through exceptionally tall herbage, a tunnel-like passage results.

These trails are narrow, seldom more than two or three inches in width, and connect up each system of burrows with the next. In a field of an acre in extent, there may be five or six woodchuck burrows. These will connect with one another by well worn paths. Solitary animals, especially old males, will have as many as three sets of burrows over their feeding ground, and wander widely in searching for food.

The approach to the nest is usually made through these trails. Under cover of rank vegetation, or even in fields with low growing plants, the animals keep to these narrow files when leaving or approaching their burrow. When the hay is cut, and the meadows and fields again leave woodchucks exposed, they still resort to these well worn runways. An animal may be feeding fifty yards from the den, and surprised, make for its home. In spite of a short cut that would save it several seconds in reaching the sanctuary of its underground retreat, it will yet confine its route to the lane it has used so long. This has been the undoing of many woodchucks, as a good marksman can frequently have time to place a fatal bullet before the animal has "denned."

In gathering nesting material, the woodchuck may go a long or a short distance from the nest, depending directly on the accessibility of available material.

On April 4, 1931, a large "chuck" was observed gathering grass for its nest. This animal tore at the already loosened grass with its forepaws, then bit it off, or pulled it up with the teeth. It never ventured more than twenty yards from the hole, and spent about from thirty to sixty seconds securing material on each trip. It was observed from 4 until 5 P.M., in which time it made twenty-one trips, each time carrying the equivalent of a small fistful. When I left it was still engaged in carrying in bedding material. This animal had young out

of the den on May 19, when they were estimated to be six weeks of age. Thus she was making a nest, or repairing one, about a week or ten days before the young were born.

Another individual was seen carrying large mouthfuls of dead oak leaves to its den on August 15, 1929. It made about twelve trips per hour, and travelled seventy yards for its nest material.

In collecting grasses for the nest, the woodchuck will frequently manipulate the loose dry grass with its paws, while holding it in its mouth. The loose ends are tucked in and folded, so that no stray piece will be lost on its journey to the den.

OTHER OCCUPANTS OF WOODCHUCK BURROWS

The woodchuck plays host to a veritable army of mammalian intruders, all seeking a sanctuary against the elements, protection from their enemies, or a place in which to rear their young.

RABBITS

Cottontails utilize the burrows of woodchucks frequently. During the fall they spend most of their time in a "form" above ground, but with the advent of snow and severe weather the cottontails repair to a woodchuck burrow. They likewise make use of these holes during the spring months, and possibly bring forth their young upon occasion in these underground retreats. They, however, generally have the young in a slight depression of their own making.

SKUNK

The skunk is an adept digger, but seemingly prefers to usurp a "chuck" burrow when such is available. They may at times be found in the same hole with a woodchuck. Skunks will frequently alter these burrows, more especially the nest chamber, enlarging it to accommodate four or five individuals, as is their habit during the winter season.

Fox

Red foxes probably frequently make use of the dens made by woodchucks they have conquered. At least one instance of this was furnished near McLean, N. Y., on May 3, 1925. A lactating red fox was collected at the entrance to a woodchuck burrow. When the burrow was excavated, four young foxes, about five weeks old, were secured.

This was in an open field, in good woodchuck territory, and had all the earmarks of a remodeled woodchuck home.

WEASEL

Weasels venture into the burrows of woodchucks, at least rather frequently in the winter and spring months. Tracks in the snow often reveal such records. Definite records of spring use have been secured twice. On April 8, 1932, I saw a woodchuck at the entrance to a hole bordering a large stream. A trap placed well within the hole, with a rock completely blocking any escape, caught during the night an adult male *Mustela cicognanii*. Mr. Edward Drake took a nursing female weasel of the same species at another woodchuck hole on May 13, 1932. The hole was tenanted by a woodchuck at the time. The following day his trap held a fine male specimen of this weasel, ostensibly the mate to the animal caught the preceding night.

CHIPMUNK

On March 26, 1932, I set about twenty traps for woodchucks. There was a quantity of snow on the ground at this time. Five chipmunks, *Tamias striatus lysteri*, were caught in the morning, all rutting individuals. From their position in the trap, it would indicate that they had been in the hole, perhaps the previous night. Possibly they frequently resort to such chambers for their hibernating period, making little tunnels or pockets to the side of the chamber.

HOUSE CAT

Inside a large woodchuck hole I placed a trap on April 9, 1932. The hole had been somewhat enlarged, but without a noticeable mound at the entrance. The following morning the trap held a large house cat. The animal was a female, carrying three embryos of approximately half time development, and stomach crammed with the remains of a rabbit. Apparently the cat had made this burrow her home for some time, as old rabbit fur was strewn about. She may even have planned for the arrival of the kittens in this burrow.

It is not unlikely that mink, muskrats (near water), squirrels, and other mammals frequently resort to vacated woodchuck burrows. The writer, however, has no positive data concerning these forms.

MEASUREMENTS

The conventional measurements were taken of all animals collected. This includes the total length of the animal, the length of tail, and length of hind foot. Various methods have been adopted by field naturalists for recording these measurements. The commonly accepted way is to lay the animal on its back, manipulating the limbs to alleviate to some degree the effects of *rigor mortis*, providing this has set in. The table on which the animal is laid may be conveniently marked off. If a ruler is to be used, a steel one is preferable.

The effect of gas collecting in the intestines of dead animals has a tendency to bloat them, and shorten the body length. This, together with the effects of *rigor mortis*, gives us measurements that are not a true index to the correct size. For example, an animal measured immediately after death in the evening, or not later than two hours after it has been killed, will have an apparent greater length than the same individual measured the following morning, when stiff, or perhaps at noon of that day, when decomposition permits a ready manipulation of the animal. The measurements, but more especially the body length of the creature, will vary as much as fifteen per cent from its normal size, taken under such conditions as outlined above. The hind foot is little affected by these conditions, and for this reason is a better index of the animal's true size, and in some cases, its age. In woodchucks, the hind foot becomes fully grown early in life, and like other rodents, we find little variation among adults. When an exception to this occurs, it is not apt to be well marked.

The tail measurement is accomplished by placing a ruler on the upper side of the tail, at its base, then bending the tail at right angles to the body. The tuft of hairs at the tip is disregarded in calculating this measurement.

Throughout life the tail tip is especially subject to injury, as has been recorded in *Microtus* by Howell (1924). This is a frequent instance observed in the males, which may engage in battle with one another over a likely mate, a piece of territory, a desirable hole, etc. Numerous animals have shown beyond any doubt upon examination, that their tails have been foreshortened in one manner or another. In measuring this appendage, all injured tails have been disregarded in the final compilation of data in order to determine average measurements for a large series.

MEASUREMENTS OF ADULT WOODCHUCKS

All specimens included here have been taken in central New York, within a few miles of Ithaca. The measurements have all been recorded by the writer, who alone is responsible for them. The animals listed include subadults, (that is, in their second year), but are for the most part sexually mature, and very old individuals. In general, collectors have a tendency to preserve the largest individuals of a species. This may account for the measurements and also the weights, which appear in many reports, averaging higher than those cited below.

The average measurements for 167 males, measured in the flesh within an hour or two of death, are as follows: total length, 22.5 inches (25-19); tail, 5.15 inches (6-4.25); hind foot, 3.15 inches (3.5-2.75).

One hundred and thirty-one females average: total length, 22 inches (25.25-18); tail, 5 inches (6.1-4.2); hind foot, 3 inches (3.4-2.6).

Averages for 298 individuals of both sexes are: total length, 22.2; tail 5.12; hind foot, 3.1.

WEIGHTS

It is to be expected that weights of animals will vary considerably more than measurements. Such factors as quantity of food in the alimentary tract, amount of fat, presence of embryos, and the like, tend to make this figure quite variable. There are lean "chucks" in a land of plenty, as there are fat individuals in sparse cover. It is readily conceivable that we should expect to find, at times, two individuals with the same body measurements, but one weighing practically again as much as the other. This discrepancy is largely offset when we use large numbers to tabulate weights. Under discussion of food, the writer has pointed out the enormous capacity of a woodchuck's stomach. It is quite possible for this organ to hold a pound and a half of green matter at one time. It is not unusual to find over a pound of food in an animal. Assuming the stomach contents of an average woodchuck to contain half a pound, this being a very conservative estimate by repeated weighings, we must subtract this in order to determine the vital weight of each animal. Furthermore, a woodchuck carrying five embryos within a day or two of birth, would have an increase of five ounces in its weight on account of this added burden. It does not seem necessary to empty each stomach before weighing the

animal, for mammals, except the larger game animals, are customarily weighed in the flesh before being dressed or skinned.

Specimens collected in the late summer and fall have an abundance of fat, this sometimes weighing a not inconsiderable amount, as compared with animals secured in the spring.

Such handicaps in using weights may tend to produce misleading results in attempts to determine age, or any other phase. Nevertheless these records are as important as the conventional external measurements.

The following weights have all been made by myself, on a dial scale, graduated to half ounces. From time to time the scale was checked with others by known weights, and proved to be quite accurate.

MONTHLY WEIGHT AVERAGES FOR ADULT WOODCHUCKS

MONTH	MALES		FEMALES		MALE AND FEMALE AVERAGES	
	NO.	WEIGHT	NO.	WEIGHT	NO.	WEIGHT
March	4	5 lbs. 4 oz.	3	4 lbs. 10 oz.	7	5 lbs. 10 oz.
April	51	4 lbs. 13 oz. (6-13, 2-12)	38	4 lbs. 6 oz. (7-9, 2-10)	89	4 lbs. 11 oz.
May	70	5 lbs. 3 oz. (8-7, 3-6)	43	4 lbs. 6 oz. (7-11, 2-15)	113	5 lbs. 4 oz.
June	10	7 lbs. 2 oz. (8-8, 4-8)	17	6 lbs. 2 oz. (7-14, 3-8)	27	6 lbs. 4 oz.
July	21	7 lbs. 13 oz. (12-9, 5-1)	12	7 lbs. 8 oz. (9-4, 6-4)	33	7 lbs. 12 oz.
August	26	8 lbs. 2 oz. (11-10, 6-2)	21	8 lbs. 3 oz. (10-4, 6-9)	47	8 lbs. 2 oz.
September	9	10 lbs. 4 oz. (11-1, 7-1)	9	9 lbs. 11 oz. (11-0, 7-12)	18	9 lbs. 15 oz.

Numbers in parenthesis represent extremes for the month.

The average weights of 326 adults collected from late March to late September, during 1931 and 1932, is six pounds and three ounces. Of males, 191 adults average six pounds and four ounces, while 135 adult females average six pounds and one ounce.

Undoubtedly the weights of woodchucks that have appeared from time to time in the literature of sporting magazines have been, for the most part, those of large animals. Sportsmen usually wish to break records with their trophies, to boast of some big animal brought down by clever stalking and good marksmanship. Moreover there is

an incentive to record the weights of animals killed in the fall rather than in the spring because of the greater size of these beasts. I have tried to substantiate the records of woodchucks weighing fifteen pounds by actually securing such animals, or getting such information from reliable persons who have actually weighed the largest specimens.

It is significant, that of over three hundred adult animals carefully weighed, only eleven reached ten pounds or more. The heaviest, a huge male taken on July 25, 1932, weighed twelve pounds and nine ounces. The stomach contents of this individual accounted for three-quarters of a pound.

Mr. Harold Rightmyer, who has killed well over seven hundred woodchucks in the area where this study has been undertaken, recalls that his largest specimen, an August animal, weighed just fifteen pounds. He thinks the weight of one he once shot must have exceeded this maximum.

In early October, 1922, Mr. Owen Beckwith, of McLean, N. Y., shot a very large individual. He was struck with its size and found that its actual weight was fourteen pounds and four ounces. The contents of the stomachs of such specimens might easily have weighed a pound, or even exceeded that weight. We are forced to believe that a very large woodchuck (*Marmota monax rufescens*), at least in central New York, will scarcely weigh more than thirteen pounds, while the average weight of the largest animals is usually a pound or two less.

COLORATION

NORMAL COLORATION

In the coat color of *Marmota monax rufescens* we find much variation. Essentially there are two types of hair, the long coarse guard hairs, that project considerably beyond the soft wool-like underfur. This shorter fur is quite thick, but is altogether lacking on the belly. Howell (1915, p. 25) has given a good description of the normal coloration of this form, but the variations are so great that a few may well be described. In general, throughout central New York, woodchucks may be roughly divided into two color groups. The first is a light form of a somewhat grizzled appearance, all the long hairs being tipped with light buff. The other phase, less common, is a dark form, the long hairs being tipped with chestnut brown. Individuals are

often so characteristically marked that they may frequently be recognized in the field.

A large male preserved in the museum of Cornell University, No. 1157, is very dark throughout, almost black, except the sides of the face, shoulders, and flanks, the long hairs of this region being tipped with white. The animal is reminiscent of a silver fox.

The inner forelegs and chest are often a Mars orange; this bright color is less pronounced in dark individuals. Rarely the long hairs are lacking. Their occasional absence gives to the animal a decidedly woolly appearance. Two animals were taken in this condition.

ALBINISM

White woodchucks are not common, but two are in the collection of Cornell University. Both are pure albinos. I have seen about ten in all, represented for the most part in college collections.

MELANISM

The black phase is rather well developed in *Marmota monax rufescens*. No pure black specimens have been recorded. All have had the head lighter than the remainder of the body, and usually a mummy brown. Three such as this have been collected by the writer and three more seen in the field. A black individual which had been under observation had four normal colored young, while another female that was black had two black young and two normal colored individuals. Harold Rightmyer collected the two black young but did not succeed in shooting the old one, although he saw her many times. It is Rightmyer's impression that black woodchucks are far less common at present (1931-32) than they were ten years ago. In former years he used to shoot an average of fifty "chucks" a season, of which two or three would be black. During the season of 1931 and 1932 he shot nearly four hundred, and of these only two were black. Out of a number of over seven thousand woodchucks seen in the field, only six have been black.

VIBRISÆ

The woodchuck is equipped with well developed black bristles, similar to other members of the family. These are for the most part situated on the face, in keeping with the established axiom that sense

organs are usually to be found most prominently about the head and forelimbs. There are four sets of these vibrissæ on the head.

The bristles of the mystacial group are the best developed and are found on the upper lip. These normally number fifteen, and the longest average forty millimeters in length. The superciliary group, numbering five bristles, is found just above the fore part of the eye. These average from thirty to thirty-five mm. A third group, the malars, number eight prominent hairs, and average sixty mm. They are situated midway between the eye and the angle of the mouth. The interramal set of six large hairs and two or three smaller bristles measure from thirty to forty mm. There are two large carpal bristles.

MALOCCLUSION

Malformed incisors, in many rodents, are not infrequently found. Woodchucks are no exception in this respect. Many instances have been recorded where the upper and lower incisors, deflected in some manner, have grown without restraint, and have even at times effectively locked the jaws.

Of well over five hundred woodchucks observed in the flesh, five individuals, or one per cent, have been found to have well developed cases of malocclusion. The most pronounced instance of this anomalous condition is in the skull of an adult animal in the Cornell University Museum (no data). The right upper incisor forms the arc of a perfect circle, and is embedded in the palate just anterior to the first left cheek tooth. The left upper incisor parallels the right incisor for half its length, where it leaves the mouth and pushes outside, terminating thirteen mm. laterad of the infraorbital foramen. These two incisors have an average length of fifty-seven mm., while in a normal animal the upper incisors measure eleven to thirteen mm. In this same individual the left lower incisor is deflected rather sharply to the right, reaching far outside the mouth. The tip of the tooth is considerably flattened, while the length of the incisor is forty-seven mm. The right incisor is absent.

In another individual, (Plate XX, fig. 1), the two lower incisors have grown sharply to the right, the right incisor passing under the shorter left incisor. The right incisor is moderately sharp at the tip and measures forty-eight mm., while the blunt left incisor is but thirty-four mm. The left upper incisor has curved under and grown up, piercing the muscles and flesh in the region of the lachrymal canal,

and protrudes here for thirty-four mm. The upper right incisor curves ventrad for a short distance, then turns upward and is imbedded midway between the anterior palatine foramina and the first left molar.

A third individual had the upper incisors missing. The lower incisors curved outside the mouth, both to the right side, for a distance of thirty millimeters.

Other instances have been recorded by the writer of malocclusion in the woodchuck, but they are not as pronounced as these.

POLYMASTISM

Normally the woodchuck is equipped with four sets of functional mammae. Two pairs are pectoral, one is post abdominal and one pair is inguinal. Rarely does it happen that conditions differ in this respect.

Two instances of supernumerary nipples have been witnessed by the writer. It accounts for one in every two hundred and fifty woodchucks examined. In both cases the extra pair has been located between the normal abdominal and inguinal pair, and in both instances these accessory glands were functioning.

Polymastia and hyperthelia are not uncommon in man. Possibly this condition is common to other mammals. The many recorded instances in *Homo* have been the result of thousands of workers in the medical profession tabulating their data. Far fewer are at work with the smaller mammals. With further studies, we may find the presence of extra teats not uncommon in most of the smaller mammals.

MOLT

An annual molt occurs, occupying a long drawn out period from late May until early September. The young of the year molt later than the adults. Individuals born the same year may go into winter quarters in a half-shed condition. Part of the body, usually the posterior portion, may have new fur, while the anterior end may possess the juvenal coat of summer.

Upon emerging from their prolonged winter sleep, the fur of the woodchuck is long and thin, being somewhat soiled and faded in appearance. Often large bare spots appear, possibly due to the friction of the walls of the hibernating cell.

Howell (1915) says of woodchucks in general: "There seems to be

no uniform method of molting, the new pelage sometimes appearing in patches on various parts of the body in an adult individual of *M. monax preblorum*, taken July 11, the new pelage coming in over the entire upperparts, farther advanced on the fore back and shoulders." This is just the reverse of what I have found in my studies of *rufescens*. Almost without exception, the molt commences with the tail. This appendage becomes thick and bright, in marked contrast to the frayed and faded body fur. Paralleling this, the new fur appears about the facial region. The hind quarters are next clothed in new fur, and this area gradually embraces the upper back region, advancing toward the shoulder, while the fur of the upper head, throat and neck are replaced with new fur, slowly retreating caudad to meet the new fur of the back. The fore shoulder and humeral region are, in general, the last parts of the animal to secure the thick new fur of late summer.

This is, in general, the manner exhibited in fifty-three individuals when collected during the molt.

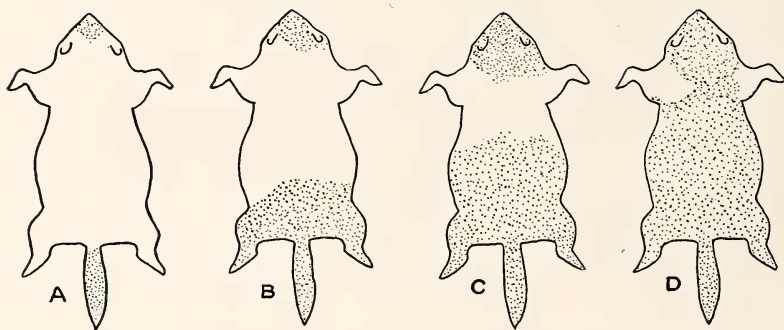


FIG. IX. Captive Woodchuck showing progression of molt. A, June 30; B, July 10; C, July 16; D, July 20.

The change of fur is accomplished by new hair replacing the old, quite irregularly, over one part of the body at a time. Practically all individuals have shown, when the molt has been well instituted, the fore part of the animal in the old fur and the hindquarters in the new. This is not confined to small spotty areas, where the molt is incipient, but rather to the whole portion undergoing a change. Thus, if we should pick up an animal half way through the molt, we should expect to find half the body (*i.e.*, the caudal half) in bright new fur and rather sharply demarked from the shoulder region.

The earliest date for a molting animal is June 12, 1932, when a

large female proved to have much new fur. It is very likely the commencement of the molt was instituted in late May. Few individuals commence to shed their fur this early, but by early July the annual pelage change has commenced in earnest. Adults taken during the middle of this month have the molt half completed. There is a wide difference between certain individuals in the time of molt, regardless of the apparent condition of the animal, the amount of fatness, or any other visible factor. Of two adult individuals taken on August 1, 1932, one had completed the molt while the other had not commenced the change. On this same date, a subadult was taken that had shed far more irregularly than is common with these rodents. Two patches of old fur remained on the shoulder, while a large patch of the previous year's fur remained on the rump.

On August 6, 7 and 8, 1932, eight adults had completed the change, while eleven young had not commenced to molt. On August 12, 1932, four adults had undergone the entire molt, while of four young, two were almost through the change and two had renewed only the fur of the tail.

By early September, most of the adults have molted, and about half the young have completed the change.

In general the adults get their new fur first, then the subadults, followed by the young of the year. The young do not always renew their coat the first year, since they may have it half completed when cold weather overtakes them and they retire for the winter sleep. Thus early in the spring it is quite possible to take young animals of the previous year, with half the body clothed in long fur, the other half in the much shorter new fur of the previous fall.

Complete molting in a captive individual occupied three and a half weeks. A young individual marked and released August 2, 1932, had no new fur. When recaptured on August 19, the posterior part of the body was in new fur and the molt had been half consummated.

FOOD AND FEEDING HABITS

The following list of foods recorded as eaten by the woodchuck is in no way exhaustive. For the most part, it is from one observer's notes taken over a period of several years. As might be commonly supposed, clover and alfalfa form the bulk of the green food eaten during the summer months, but these are not necessarily the most important, nor do they serve the vast majority of "chucks." Stomach

analysis of rodents is often unsatisfactory. The food, in most instances, is finely ground up and comminuted, so that certain identification is usually not definite. By emptying the contents of the stomach into a pail of water, stirring it vigorously so as to break up the compact mass, the distinegrated parts that float to the surface may readily be picked out. Frequently, enough of the leaf, flower, or stem, exists to make immediate identification possible. Smelling the mass will prove a ready means of identification for some foods, but this method is not often of much value.

Direct observation of the feeding animal is a very useful procedure in attempting to determine selected food plants. So seldom can a wild animal be watched while feeding that this method proves of great value whenever possible. Frequently animals, when shot, have a piece of vegetation in the mouth. There is little chance of mistaking such parts. About the den, the choicest vegetation is often cropped close. This likewise gives us a method which is useful.

LIST OF FOODS

Vallisneria spiralis Eel Grass. During early July, 1930, near Cedar Spring, Clear Township, Adirondack Mts., N. Y., Drs. W. Senning and A. S. Hazzard saw a woodchuck on a log jutting into a small pond. It was feeding upon this plant.

Phleum pratense Timothy. The leaves and stem are eaten.

Agropyron repens Quack Grass. The leaves of this obnoxious grass were being eaten by a large woodchuck observed in January. This is the only record I have of the animal feeding on this grass. I should like to report more.

Rumex Acetosella Sheep Sorrel. Leaves eaten, especially in spring.

Polygonum sagitatum Tear Thumb. Leaves eaten in late summer.

Fagopyrum esulentum Buckwheat. Young plants are eaten avidly. Ripening grain often forms a considerable part of the stomach contents in late August.

Ranunculus acris Tall Buttercup. Leaves commonly eaten.

Brassica arvensis Wild Mustard. Not a common food plant, yet furnishing one of the first greens of early spring. The basal leaves are eaten, and rarely the flower heads.

Barbarea vulgaris Winter Cress. The leaves are eaten in May.

Geum strictum. The leaves are eaten.

Rubus sp. Wild Blackberries and Raspberries. Stomachs of woodchucks shot in August disclosed the red remains of ripening blackberries. In many instances woodchucks travelled considerable distances from their home den for these delicacies, when all about the den succulent greens were present to tempt them.

- Agrimonia* sp. Agrimony. The leaves are frequently eaten.
- Prunus serotina* Wild Cherry. Leaves, bark, flower, and fruit. The wild cherry furnishes bark in late winter, flowers and leaves during spring, and enticing cherries in late summer. Woodchucks have been taken with a half pint of this fruit in their stomachs.
- Trifolium pratense* Red Clover. The most important food throughout the season. Stems, leaves, and flower heads, are eaten.
- Trifolium repens* White Clover. Leaves, stems, and flower heads. An important food of the woodchuck.
- Melilotus alba* Sweet Clover. Leaves, stalks, and blossoms are eaten.
- Medicago sativa* Alfalfa. Leaves, stems, and flower heads are eaten. A very important food item.
- Rhus typhina* Staghorn Sumach. During March the bark of this tree is frequently chewed upon by woodchucks. It is loosened by scratching with the fore paws.
- Malva rotundifolia* Common Mallow. Leaves are sometimes eaten.
- Hypericum perforatum* St. John's-Wort. Leaves are eaten in the spring and early summer.
- Oenothera biennis* Evening Primrose. Basal leaves are eaten in early spring.
- Plantago major* Broad-leaved Plantain. Plantains are eagerly devoured, the stems and leaves being for the most part sought. Often in the clover patch, woodchucks will pass by the leaves of red clover to seek out the smaller plantain, hidden beneath the larger plants. They apparently favor it to clover.
- Plantago lanceolata* Narrow-leaved Plantain. As above.
- Plantago rugelii* Red-stemmed Plantain. As above.
- Solidago bicolor* Goldenrod. On September 7, 1932, a "chuck" was seen feeding on the basal leaves of this plant.
- Solidago* sp. Basal leaves of several species are eaten.
- Aster undulatus* Aster. The basal leaves are eaten.
- Erigeron annuus* Daisy Fleabane. Basal leaves are eaten in early spring.
- Daucus Carota* Wild Carrot. Leaves are eaten.
- Chrysanthemum Leucanthemum* White Daisy. Leaves are frequently eaten. An important food in the fall.
- Tussilago Farfara* Coltsfoot. Flowers are eaten. An important food when in bloom.
- Taraxacum officinale* Dandelion. Leaves, stems, and flower heads are eaten. Without question the most important food of early spring. Captives prefer leaves of this plant to that of any other food. The principal food in the stomachs of animals collected in April and May.
- Lactuca canadense* Wild Lettuce. The leaves are eaten.

Hieracium aurantiacum Devil's Paint Brush. The acrid and bitter juices of this densely hairy plant are not disagreeable to the woodchuck, for I have often observed them feeding on the leaves, and specimens that have been shot have often had the leaves in their mouth.

Cirsium arvense Canada Thistle. The small young leaves of this prickly plant are found in the stomachs of woodchucks upon occasion.

Hickoria sp. Hickory. The bark of young hickories is sometimes sampled in early spring.

Acer sp. Maple. The same applies to this plant.

Oats, wheat, and corn, are among some of the grains that are principally eaten. Among the truck crops, beets, carrots, peas, beans, tomatoes (one record), lettuce, celery, cabbage, and turnips, are consumed. Melons are frequently attacked, while strawberries and cultivated cherries are eaten avidly. Apples form an important part of the diet in late summer and fall.

The animal food of woodchucks accounts for only a small portion of the fare, considerably less than one per cent. Woodchucks have frequently been accused of chasing, killing, and eating poultry. How often they are a contributing factor in the death of chickens it is difficult to say. However, there can be but little question that they sometimes eat young birds as most rodents would, if given the opportunity. Yet the nests of song sparrows, meadowlarks, and pheasants, together with other ground nesting birds, have been readily available to a number of woodchucks I have had under observation. To my knowledge, the young birds were never molested by these large rodents. Hatt (1930) found a nestling bird in the stomach of a woodchuck.

On October 6, 1932, a woodchuck was collected that had badly malformed incisors. In the mouth and stomach were a score of snail shells (*Ileiosoma antrosa*). Possibly the woodchuck had to feed on these molluscs because of the difficulty experienced in eating green matter. Furthermore, it is possible that shells were an aid to digestion, as the animal could do little chewing with such a bad case of malocclusion.

Woodchucks occasionally eat insects. Two animals had fed sparingly on grasshoppers (*Melanoplus femur-rubrum*) while June bugs are sometimes eaten (Gianinni, 1925).

It is customarily assumed that flesh eaters have relatively short

intestinal tracts, while the enteria of herbivores are proportionately longer. Some clue may be given us to the woodchuck's carnivorous tendencies by comparing the length of the intestinal tract with that of other rodents where the food habits are likewise relatively well known. Two flesh eaters are included for comparison. The measurements are in inches, and the figures represent two individuals in each instance.

SPECIES	INTESTINAL LENGTH	BODY LENGTH	RATIO OF		TYPE OF FOOD
			INTESTINAL	LENGTH TO BODY LENGTH	
Weasel (<i>M. cicognanii</i>)	40	10	4 to 1		Carnivorous
Skunk (<i>Mephitis nigra</i>)	79	15	5.3 to 1		Omnivorous
Grey Squirrel (<i>S. carolinensis</i>)	102	10	10.2 to 1		Herbivorous
Red Squirrel (<i>S. hudsonicus</i>)	57	7.7	7.4 to 1		Chiefly herbivorous. Eats meat on occasion
Woodchuck (<i>Marmota monax</i>)	222	18	12.3 to 1		Herbivorous

AMOUNT OF FOOD EATEN

The stomach contents of 146 animals have been weighed in the field. These average 8.6 ounces, or slightly more than a half pound. The vast majority of the animals were shot while feeding, so this is not altogether a true index of the amount of food the woodchucks might have consumed. Many of the animals had but three or four ounces of food in the stomach. We know that an adult woodchuck's stomach is capable of holding more than a pound and a half of green matter.

Nine of the above individuals had more than a pound of matter in the stomach, while one had eaten twenty-six ounces of food. Young animals usually had more in their stomachs, proportionately, than the adults. The animal with the stomach contents exceeding a pound and a half had a gross weight of six and a half pounds. Without food, this animal weighed not quite five pounds. Thus it will be seen that it had eaten just one third of its weight. A subadult male taken on April 24, 1931, had eaten thirty-five per cent of its body weight, while another male, collected on May 6, 1932, had eaten twenty-nine per cent. Frequently we have taken woodchucks, whose stomach contents would have equalled a quarter of the animal's weight. Probably

a pound a day in green matter is necessary to keep a woodchuck fit. An adult sheep will eat from nine to ten pounds of green matter daily.

TIME AND MANNER OF FEEDING

The greatest amount of food is consumed during the late afternoon hours. Woodchucks commonly feed during the early morning, and while they may appear at irregular intervals throughout the day for feeding purposes, the hours from 5 P.M. until dark are the most active ones. Young animals, growing rapidly in the late summer, are apt to make use of almost any hour. Animals that have been shot at, repeatedly, feed entirely in the early morning or do not commence their feeding until dusk has made accurate shooting impossible.

Woodchucks employ their fore paws in feeding on the taller plants, such as red clover, alfalfa, grains, berries and leaves. The part desired is secured with one fore paw, pulled toward the animal and devoured. With apples, peas, and beans, they may hold the food in both hands while feeding.

ENEMIES

The woodchuck, because of its size, has few foes. Most of these it can guard against by a hasty retreat into its underground labyrinth, but occasionally it is outwitted by one of the larger mammals.

Of vertebrate enemies, the fox, man, a few hawks and owls, and an occasional snake, are the principal foes with which the groundhog has to contend. Among the lesser enemies—the parasites—I have found two or three external forms and as many internal pests.

RED FOX

There can be but little question that among the larger animals, not barring man, the red fox ranks first as a destructive agent of the "red monk." The breeding season of this valuable fur-bearer closely coincides with that of the woodchuck, and young foxes are fed in large measure upon the meat of this rodent, where it is at all abundant. At this season, the home den of a red fox may be literally strewn with the remains of woodchucks. Two fox dens visited by the writer in May had a large representation of these animals about the hole. Mr. John D. Smith, of the Boston Society of Natural History, informs me that by actual observation, he ranks the woodchuck as the most important food of these red-robed fur-bearers during the spring and

summer months. Repeatedly he has found the partly eaten carcasses of woodchucks in the area about the dens, which are particularly abundant in the Boston region. It sometimes happens that the fox will kill a groundhog, find the den of the dead animal to its liking, and with a little effort, enlarge the burrow and make its home there.

MAN

In all likelihood, man kills more "chucks" than the fox. Because of his cultivated fields, acres of clover and alfalfa, and unfavorable attitude toward the fox, however, he compensates in large measure for the havoc he does with trap and gun. In some areas man carries on incessant warfare with the marmot, but in other parts of his range, the woodchuck is almost unmolested. Dogs, because of man, are distributed widely throughout the woodchuck's range, and take a large toll. The clearing of the forest by man, with the resultant large acreage of open fields and meadows, and rolling country devoid of trees, has done much to encourage the woodchuck. His range has spread widely over this rich domain.

SNAKES

One of the state gamekeepers of Pennsylvania (Pennsylvania Game News, Aug. 1931, Vol. 2, p. 5), killed a large rattlesnake, in the stomach of which were two young groundhogs, respectively six and eight inches in length.

INTERNAL PARASITES

I have repeatedly made blood smears of woodchucks and critically examined the corpuscles after staining, in the expectation of finding unicellular organisms. None have ever been encountered, but probably from time to time throughout its life span the woodchuck is host to the invasions of many protozoans.

Among parasitic worms, nematodes appear to be most abundant in the intestinal tract, more especially in the rectum. These small threadworms, almost colorless, may number several hundred in an individual, but more often fewer than a score are to be found.

In the stomach, one sometimes finds a number of small, red roundworms, attached to the mucuous lining. More often they are absent, and they never reach the abundance recorded in the skunk and the fox.

EXTERNAL PARASITES

Among the ticks, only a single species has been determined, that being referable to *Ixodes hexagenia* var. *cookei* Pack. Practically every woodchuck I have examined has had these ticks present, sometimes in considerable numbers. As many as 69 specimens have been taken from one woodchuck and probably many more were overlooked. Apparently no particular place is sought for their attachment, unless it be the axillæ and sternal region, where they are most frequently encountered. Woodchucks do not appear to be unduly disturbed by these little demons. The groundhog is not their only host, for the ticks will quickly attach themselves to man, where the capitulum is soon buried. If this structure is not removed when the tick is destroyed, serious results may be expected. The writer was the temporary host for one of these arthropods on September 5, 1931. A tick attached itself to the anterior bend of the right elbow, and was removed shortly afterward, but not without leaving a small piece of the capitulum. A year later the site of the tick's attack still remained visible, while pruritus caused much discomfort over a wide area about the site. In three instances children have been utilized as a host by *Ixodes*, which may live for a long period without feeding after removal from the normal host. In the case of the children, no serious effects were felt, but the animals were removed in a very short time after their attachment to the human host. Great care should be exercised in handling these rodents, because of the likelihood of getting these arthropods on one's person.

Most woodchucks have their allotment of fleas. While several hundred have been taken from the animals, all prove to be one species, *Ceratophyllus arctomys* Baker. It is most frequently seen about the anal region and the head, but possibly observation for parasites is much easier in these areas of shorter fur or less hair. What has been said of the tick regarding its attacks on man, might be repeated here. It has the pernicious habit, common to all fleas, of taking a nip here and another there. Its uncommon ability to escape detection or to elude pursuit makes it a most undesirable tenant. It may be extremely abundant on one animal, and entirely lacking on another. I have taken over twenty fleas from a single woodchuck, and missed as many more.

CUTEREBRA

Seton (1929) says of the woodchuck, "Even the *Cuterebra*, for some strange reason, lets it alone." Such is not always the case. An adult collected on July 24, 1931, had a bot larva 14 mm. long on the right side of the head, below the right ear.

A young woodchuck, taken August 17, 1932, had a *Cuterebra* larva completely plugging the right nostril and filling the nasal passage, enlarging that area enormously, and had at the same time the left nostril almost closed, because of the pressure brought to bear upon it. Yet the "chuck" appeared to be in good condition, and was as large as an average young animal of that date.

These are the only two individuals among five hundred that exhibited the effects of this enormous fly larva.

A QUESTIONABLE PARASITE

A curious little grey fly of the genus *Pegomyia*, not unlike a house fly, but considerably smaller, is found in abundance on practically every "chuck" collected in the summer. It is a member of the family Anthomyiidae, calyptate flies of leaf-mining habits. With binoculars, one can commonly see woodchucks sunning themselves and observe these flies crawling about rather aimlessly on the fur. More than a hundred may sometimes accompany a single individual. It is this insect that makes the "chuck" paw at his face, shake his head and at times appear ill at ease. Especially is this true when the infestation is very pronounced. It is a curious relationship, and I cannot account for the connection. Possibly the fly gets food from the dry dead epidermal tissue common to any woodchuck's hide, or it may secure some moisture from the rodent.

HIBERNATION

The subject of hibernation has received a great deal of attention, and voluminous reports dealing with the subject have been written. Yet we are still far from an exact knowledge of the cause of this phenomenon. Many explanations have been accorded it, but few have stood the trial of time.

CAUSES OF HIBERNATION

Much experimentation and elaborate hypotheses have been promulgated concerning the motive for hibernation. The principal arguments as to the direct cause have been those of lack of food and low temperatures. We cannot attribute either of these to the disappearance of a large percentage of the woodchuck population during late September. The warm days and cool nights of Indian summer have but begun, and the fields are clothed in tender plants, succulent and green because of the autumn rains.

Apropos of this annual call to the earth, we might review a few of the suggestions of other workers. Much is pure speculation, while more is the result of careful observation. Simpson (1912) carried on experiments with woodchucks and decided that food was the controlling factor, because animals supplied with an abundance of food did not hibernate. Fatness in ground squirrels and marmots induces hibernation, states Cleghorn (1910), who does not consider lack of food a contributing factor. In his detailed studies of the Columbian ground squirrel, Shaw (1925) is certain that both hibernation and aestivation are brought on by a lack of water and green food. Rasmussen (1915) verified the studies of DuBois (1896), who concluded that autonarcosis was the principal cause, induced by an excessive amount of carbon dioxide in the blood and tissues.

That the reduced size of the pituitary body during hibernation is the result of physiological inactivity and therefore the principal cause of the profound winter sleep has been held by Cushing and Goetsch (1913). Both Rasmussen (1921), by his experiments with hibernating woodchucks, and Mann (1916), with striped ground squirrels, found no evidence to support the theory of Cushing and Goetsch. Later Rasmussen (1923), and Sheldon (1924), found the so-called "hibernating gland" to be a form of fat, having nothing to do with the winter sleep.

Finally Wade (1930), with characteristic thoroughness, has carried on elaborate studies of four species of western ground squirrels. He found captive ground squirrels hibernating equally well in rooms with a high relative humidity and with very dry air. Squirrels supplied with an abundance of water and moist foods had hibernated. Squirrels hibernated in well lighted rooms, while others remained awake and active in darkened rooms. Animals in well ventilated rooms became

torpid, disproving the importance of confined air as a necessary condition for torpidity. One of the contributing factors inducing hibernation, Wade believes, is the relative fatness of the animal. When they become very fat they approach the lethargic state.

I cannot help but believe that this latter view,—the accumulation of a necessary amount of fat,—is a contributing cause, if not the paramount reason. It is readily observed that young woodchucks, of the year, are always the last to be abroad in the fall, and are the lean ones, sometimes practically devoid of fat. For that very reason they possibly do not have the urge to become lethargic and to commence the period of somnolence. Their food has been converted into growing tissue, thus prolonging the deposition of adipose tissue. I have observed the same to be true of jumping mice (*Napaeozapus*), the young always hibernating later, and being with less fat than the adults. This probably accounts for the animal's presence later in the fall. It must put on a protective coat of fat to withstand the long period of dormancy and, for that very reason, is abroad later in the season to accomplish that end.

PERIOD OF ENTRANCE INTO HIBERNATION

The dates of entrance into hibernation have been set for this animal by many writers. Perhaps the most enlightening of these accounts has been set forth by Merriam (1884), in his classic paper on the mammals of the Adirondack region, who has this to say:

"Along the western border of the Adirondacks he goes into winter quarters between the 18th and 25th of September, not to reappear until the middle or latter part of March. It is indeed a curious coincidence that the limits of the dormant state should so closely correspond with the periods of the equinoxes. In nine cases out of ten, he disappears with astonishing precision, within a few days of the autumnal equinox, and remains under ground until about the time the sun cuts the plane of the equator at the vernal equinox.

For this rule, there are, of course, exceptions, but they are not sufficiently frequent to in any way invalidate the accuracy of the above general statement. During very warm weather it sometimes happens, that a woodchuck may be seen sunning himself at the mouth of his hole for an hour or two in the hottest part of the afternoon as late as the first of October, but such instances are rare. In the early springs that sometimes follow exceptionally mild winters, woodchucks occasionally appear in February, but re-enter their burrows and again become dormant if the temperature suddenly falls. In southern New England

they commonly remain out until late in October and I have seen them in the Connecticut Valley even in November."

Seton (1929) regards the annual subsoil trip to be scheduled for September 30, in Connecticut, a little later in Maryland and somewhat earlier in Maine. The latest appearance recorded by this naturalist was October 17, 1908. Cram (1910) relates the trapping of one which was active on November 1, in New Hampshire.

About Ithaca, New York, the woodchucks begin their voluntary seclusion as early as mid-September. On September 20, 1932, I was in excellent territory from 4:30 P.M., until dark, and saw not a single animal. A week earlier, a dozen could have been sighted in this same area. On September 21, 1932, a single individual was observed feeding from 6 to 7 A.M.

A year earlier, "chucks" did not become scarce until the 27th of September, yet six were seen on this date. A week later (1931), Mr. Harold Rightmyer was in the field from 9 A.M. until 3 P.M. He was hunting "chucks" at this time, and collected six of twelve that he saw. All of these were young of the year. He further stated that in the past ten years he has seen "chucks" frequently after the rabbit season (October 15) had opened.

A young individual was seen on October 10, 1931, twice on the 13th, once on the 19th, and the last time on the 26th. On November 6, 1931, Edward Drake brought me a trapped woodchuck that he and his brother Ralph had seen the previous evening. They chased it into a hole, where their dog attempted to dig it out. A trap placed at the entrance to the hole caught the animal the following morning. It froze hard during the night, with cold wind and snow flurries. Apparently the "chuck" was not in his own home burrow, for in all probability he would not have ventured forth in such inclement weather. The latest records for 1932 are October 26, and November 15, 1932. Mr. Ralph Percy of Trumansburg, N. Y., caught one in a skunk trap on this later date.*

*Late fall records for 1933 are not numerous. On October 19 Robert Hart saw a woodchuck near Ithaca, N. Y. The animal was nearly one hundred yards from the den.

On October 26, 1933, two woodchucks were seen near Wilseyville, N. Y., late in the afternoon. The temperature reached 26° F. the previous night, with occasional snow flurries.

EMERGENCE FROM HIBERNATION

Merriam, in his inimitable way, has alluded to the remarkable circumstances surrounding the woodchuck's disappearance in the midst of a land of plenty, and his spring advent marked by a foot of snow and a notable absence of green food.

It is difficult to say at what date the woodchuck blunders forth, to nose about and retreat, and at what time his permanent appearance is assured. Some figures may throw light on this. I kept detailed records of all woodchuck activities during 1931 and 1932, and was in the field almost daily during February and March of these years, if only for a short time each day.

In 1924, following a normal winter, I saw an animal on February 21, near Turkey Hill, Ithaca, N. Y. Mr. Henry Reed saw one on the same day.

During the late winter of 1931, following a normal season, tracks were observed in the snow on February 22. Benjamin Rightmyer saw tracks of this animal the following day, while Harold Rightmyer, stationed at Old Forge, N. Y., in the Adirondacks, observed tracks on the 25th. On March 10, Mr. Fred Keating saw two woodchucks on Connecticut Hill, near Ithaca, and many freshly opened burrows on March 8. There was considerable snow on the ground at this time.

On March 14, 1931, while an average of four inches of snow covered the ground, woodchuck tracks were everywhere. At this date, from all appearances, they were above ground for the season.

Our records for 1932 are more complete. Following an exceptionally mild winter, with the warmest January recorded for New York State in 37 years, February was ushered in with much snow and low temperatures. I was in the field at least twenty days during this month, yet the first "chuck" sign was observed on February 26, following a previous mild night, with temperature rising to 46° F. Many holes were opened this day, and animals in general roamed about a great deal.

On March 7, 1932, a terrific snowstorm, lasting three days, caused huge drifts in the hedgerows and covered the ground to a depth of more than a foot. It snowed sporadically a bit each day, until the 17th. The temperature ranged from 10°-20° F. daily. On March 12, during a period of falling snow, woodchucks were abroad, and on March 17, many tracks were seen leading into burrows four and five feet

under the snow. From this period onward, in spite of temperatures ranging from 17° - 22° F., hardly a night passed but that signs were encountered of these animals.

CONDITION OF ANIMAL BEFORE, DURING, AND AFTER HIBERNATION

By early July, adult woodchucks have commenced to assume a layer of fat, in anticipation of the coming winter sleep. Their weights show a marked upward acceleration, and the lustrous, sleek appearance of well-fed animals has been assumed. With the new fur, the animal looks altogether different. The first fat is laid down in the inguinal region. This spreads out and covers the hind legs, more especially the upper or outside portion. While fat works over the rump, and also commences on the shoulder, the two regions are joined finally by a common layer. The region of heaviest coating lies over the hind legs and rump, where it reaches a thickness of more than half an inch (14 mm.). Coincident with this is a rapid proliferation of fat about the genital organs and kidneys. When the animal is ready for hibernation, the internal organs, caudad to the diaphragm, are concealed in a white mantle of fat. This fat is not as pronounced on the belly.

No food is stored. The woodchuck trusts to this storehouse of energy on its person to furnish it what little sustenance it will need when the long nights of winter approach.

During the long winter rest, the woodchuck's vital functions are at a low ebb.

Body temperatures drop as the animal becomes inanimate and sleep overcomes it. Rasmussen (1915) found the temperatures of hibernating woodchucks to range from 6° - 14° C. This bridged the period from December 5 to February 27. A captive female, secured in January, 1932, while away from the hibernating den, was active in an outdoor cage most of that month. With the advent of cold weather in early February, the animal went into a profound lethargic state, and the rectal temperature ranged from 8° - 17° C. The air temperatures averaged between 10° and 30° F. over most of this period. During January, with the cold nights, the animal was not especially active, but did attempt to escape on a number of occasions. During this period the rectal temperatures averaged 22° - 24° C.

While hibernating, the woodchuck is rolled into a ball. The head, resting far underneath the animal, is placed between the hind limbs,

so that the nose is brought into contact with the inguinal region. The forepaws rest underneath the animal and are more or less clenched. If the animal is in a profound torpor, it does not respond to touch.

Respiration is at a low ebb in the sleeping animal, and cannot be detected without instruments. If in a deep sleep, the animal does not awaken readily. When it does come forth from this profound lethargy, the time required is usually directly dependent on the atmospheric temperature. In a warm room this is hastened, while if the natural conditions under which the animal has been sleeping persist, the process may take several hours. Shivering usually accompanies this awakening, and the violent trembling is accompanied, in ground squirrels, and probably woodchucks, by a pronounced rapid rise in the body temperature.

It is generally considered that homoiotherism is restricted to birds and mammals. In the lower mammals, including the monotremes and to a lesser extent the marsupials and edentates, the internal control of body temperatures is less effective than among the higher forms. Recently Wade (1930), in his studies of ground squirrels, found normal, active animals to have a range of nine degrees centigrade (30° - 39° C.). Spring temperatures averaged higher than fall or winter records.

During the active season for woodchucks in the years 1931 and 1932, I took rectal temperatures of many adult animals. Some were captive, others were trapped individuals. Care was taken in all instances to keep the animal as much in a normal state as was consistent with the act of inserting the mercury bulb well into the rectum. All but nine records have been discarded, because the animals struggled in one way or another to make the readings unduly high or untrustworthy in some manner. The average reading for these nine was 37.4° C. The lowest record was 34.9° C., while the highest was 40° C., a variation of 5.1° C. Young animals had a somewhat lower reading than adults.

In all instances, a clinical thermometer was thrust deep into the rectum, and the temperature recorded when the mercury became stationary.

LOSS OF WEIGHT DURING HIBERNATION

The long sleep is not without its pronounced effect upon the animal. Chief among these is a very considerable loss in weight. I have not taken weights of individuals during different periods of their dormancy,

but the average September weights, and those secured in March, when compared, are as good an index as one could wish.

Combining the average weights of 28 young and 16 adults collected during September, we have the average individual weight of 7 lbs., 11 oz. Of 7 specimens collected in March, including young of the previous year, now subadults, and old ones, the weights average 5 lbs., 1 oz. Here is an average loss of 2 lbs., 10 oz., or of one third the original weight. If only the adult weights of the previous fall are averaged, a weight of 9 lbs., 4 oz., for 16 individuals is secured. Four adults taken in late March averaged 5 lbs., 9 oz. This results is a loss of 3 lbs., 11 oz., or nearly forty per cent of the original weight. In early April I took a gravid subadult with two embryos, that weighed 2 lbs., 10 oz. Certainly she must have lost half the original weight during the periods of hibernation, and of early spring food scarcity. The fasting period, then, accounts for a loss of weight ranging from one-third to nearly half of the fall weight. This loss is distributed over from four to five months.

SITE OF HIBERNATION DEN

In choosing a suitable burrow, or site in which to spend the winter, woodchucks usually seek a hedgerow, woods, or a steep incline in stony ground that has a southern exposure.

Merriam (1886), writing of the selections made by woodchucks in the Adirondack region of New York, gives substantial evidence to support his claim that "chucks" commonly hibernate in the woods. He says, in part:

"It may not be amiss to acquaint my readers with the reasons that lead me to believe that the majority of our woodchucks desert the meadows in autumn and hibernate in burrows in the woods. There are two facts, either of which is sufficient, in my opinion, to establish the existence of this habit. First, as will be hereafter shown, woodchucks, in this region, come out of their burrow in early spring, two or three weeks before the disappearance of the snow and may easily be tracked to their holes. Now it has been my experience (an experience covering at least fifteen years) that fully 99 per cent of those that appear before the snow goes in the spring, come from holes in the woods. Second: In the fall of the year I have opened a number of meadow burrows which I knew were inhabited up to a week of the time when the animals went into winter quarters, and almost without exception, such burrows have been found to be tenantless."

Snow lingers longer in the woods than in the open fields and meadows. Perhaps, for this reason, animals wintering in the fields would not be so likely to leave their telltale tracks upon emerging. However, in central New York, where all habitats are available except the heavy forests of the Adirondacks, my observations agree with those of the veteran naturalist, Merriam.

By observing all available signs in the fast melting snows of March, we have found the greater number leading from the burrows of hedgerows, composed principally of wild cherry, sumach, and elders. In the area studied, nearly three-fourths of the signs have pointed to this habitat as the principal winter quarters of woodchucks. Next in order are stands of mixed hardwoods, but the occupied dens border the edge of the woods, rather than some distance within the timber.

I have never seen tracks in late winter leading from open pasture land, but an individual collected in January, a large female, had hibernated in a shallow burrow in an open field. Woodchucks frequently move from the woods and establish their spring home on sunny hillsides with a southern exposure, possibly in anticipation of the ever increasing warmth of the sun, with its effect on sprouting greens.

Frequently dens are opened at an early date in pasture lands, but in all likelihood they are tenanted by animals that have travelled from the woods and hedgerows a week or two previously.

Clumps of elders, isolated in open pastures, are frequently resorted to for the winter sleeping site.

Holes are not always chosen for the winter sleep. Mr. Clark Breed, of Perry City, N. Y., says he once opened a large straw stack in an open field. Eight or ten woodchucks were found hibernating within it. Mr. Otis Brayman, of Penn Yan, N. Y., found a woodchuck that had burrowed into a large straw stack and had rolled itself into a ball near the top. It was uncovered on December 20, 1931.

INCOMPLETENESS OF TORPIDITY

In the eastern United States, with one exception (jumping mice), the woodchuck is the most profound hibernator of all mammals. Bears, chipmunks, skunks, bats, and the raccoon, all hibernate to a lesser extent and it is not uncommon in the region of central New York to see the lesser of these creatures, not omitting the bat, active during warm spells of December, January, and February.

With the mild spells common to mid-winter, even groundhogs forsake their burrow and move about. With a drop in the temperature, they resume the profound sleep which is so characteristic during the cold months.

A few examples will suffice to illustrate the extent of their winter wanderings. It must be remembered that these are the records of only a few people over a very limited part of the animal's range. Undoubtedly it is much more active at this season than is commonly believed.

DECEMBER RECORDS

Henry Reed, a farmer residing two miles east of Ithaca, saw a woodchuck the last week of December, 1924. On December 24, 1931, Mr. Charles Van Fleet, of Perry City, N. Y., saw a woodchuck. On the same day, Miss Edith Smelker saw a "chuck" near Dayton, Ohio. It was observed in the mid-afternoon, when the temperature was 40° F.

JANUARY RECORDS

Woodchucks were abroad during much of January, 1932, when an exceptionally mild winter prevailed throughout New York State. On the 7th, Mr. Wm. Mosher, of Perry City, N. Y., saw a large woodchuck feeding on quack grass, which had remained green throughout the winter. He chased the animal into a shallow burrow, where he quickly dug it out, and later presented it to me. The temperature during the previous night rose to 54° F., and was five degrees lower when the animal was first observed.

On January 13 and 14, 1932, many "chuck" holes were opened by these animals, showing that they were generally quite awake at this time. The temperatures, from noon of the 13th to noon of the 14th averaged between 49° F. and 67° F., exceptionally warm for these dates.

On January 24, 1932, the temperature ranged from 34° to 40° F. throughout the day, with a slight fall of snow during the late afternoon. Numerous holes had been opened on this date.

Aside from these records, the press contained many short notices regarding winter activities of woodchucks, notably during the month of January, 1932.

OTHER ANIMALS ASSOCIATED WITH HIBERNATING WOODCHUCKS

Mr. Benjamin Rightmyer, who has dug many skunks from their dens before this practice was prohibited by law, has frequently found woodchucks in the same burrow as skunks, but in different chambers. Mr. Lloyd Herholdt collected a large woodchuck on March 22, 1931. From the same burrow he had taken three skunks earlier in the season. It was his opinion that all were living amicably together. Mr. Charles Van Fleet, about Perry City, N. Y., has dug woodchucks out of burrows he knew to be occupied by skunks.

Mr. Wm. Mosher recalls having found a woodchuck in a hollow stump. Separating the "chuck" from a large dormant rattlesnake were some dead oak leaves. The locality was western Pennsylvania. In fact, the sudden onset of hibernation often produces strange bed fellows, friends and enemies, predators and prey.

ECONOMIC IMPORTANCE

The woodchuck commonly plays a significant role in the economics of the farm. He is at once a minor asset, and at the same time a scourge.

DEPREDATIONS

The groundhog, in relation to agricultural interests in the east, may at times play a significant part. Fond of beans, peas, cabbage, and other garden vegetables, he becomes a serious pest to the truck farmer. Repeatedly I have seen the havoc wrought in the garden patch by this large rodent. It is to the small gardener that the most serious losses come. New beans never have a chance when once discovered, and a row of plants, six inches high and twenty feet long, is an average days feed for an individual. "Chucks" are adept at shelling peas when the vines have become too tough to manage, but young pea plants are apt to suffer greatly. Mr. Ernest Mills, of the Rodent Control Division, U. S. Biological Survey, writes me concerning the depredations of woodchucks in Massachusetts. He says, in part, "Mr. J. Lawrence, Carlisle, Massachusetts, reports that in 1926 young cauliflower plants numbering 4000 were eaten by woodchucks."

I have definite records of the woodchuck feeding on celery, pumpkins, melons, squash, and carrots in New York.

Woodchucks frequently invade the corn patch, when in the milk stages, and destroy much which they do not eat. I witnessed several rows of field corn, some sixty yards in extent, that had been rifled in part of the ears. These had been partly eaten, but for the most part had simply been torn off and trampled. The corn was growing in a situation ideally situated for woodchucks. The field was far removed from the habitations of man, and the scope of their invasion faced a sloping hillside liberally tenanted with these animals. Undoubtedly the injury in part may have been the work of raccoons or skunks, both of which were well represented in a nearby woods. However, woodchucks were seen working in the corn, and it is not unlikely that they were the worst offenders.

Grains of all kinds are favored by this animal. The tender leaves of sprouting buckwheat are devoured, and the ripening grain of this same plant often distends the stomachs of individuals collected in August. Much of that which is not eaten is trampled down so that it cannot be cut.

Oats, and wheat, but more especially the latter, are treated in the same manner as buckwheat. Howell (1915) quotes Bailey, who has seen nearly an acre of oats ruined by a family of woodchucks, their trails having broken down most of the grain which they had not cut to eat.

Aside from their nefarious inroads on foodstuffs, "chucks" are guilty of other faults. The burrows made by this animal are a hazard to safe mowing, the sickle bars of the mower often being dulled or broken by the hidden mounds which the tall grass often covers. Horses, unaware of their holes in the meadow or hayfield, suffer broken legs. Large areas are of necessity left uncut because of the sprawling mounds of stone and hardened dirt at the mouth of the entrance hole.

The woodchuck has been accused of being responsible for cave-ins of railroad embankments and breaks in levees, with the resultant flooding and subsequent erosion that often follows such breaks.

As a destroyer of fruit trees, especially when these are young, the woodchuck plays a not inconsiderable role. J. A. S., writing in the "Rural New Yorker" for July 23, 1932, says, "I noticed the trunks of my two year old peach trees were badly scratched by woodchucks."

It would not be hard to give further damning evidence of the woodchucks' destructiveness. Many facts might still be piled up to show his inimical nature. But I am in haste to show the "Dr. Jekyll"

side; the good he is capable of and the benefit we experience from his presence, for I like the stolid little fellow of the meadow.

HIS BENEFITS

In spite of his disgraceful conduct at times, the groundhog has many redeeming attributes that stamp him, indirectly, as a friend of man. His very energy and tireless efforts result in the construction of many more burrows than he can use. These are in turn invaded by skunks, foxes, rabbits, and a host of other mammals. We may not think of these animals as an asset, but they bring a sizeable return to the state through the sale of hunting and trapping licenses, and in turn furnish a partial livelihood to thousands of men, both young and old, throughout the state.

Rabbits seldom dig, but resort to the burrows of other animals. Skunks are loathe to construct their own homes when a convenient woodchuck burrow may be easily remodeled. Foxes, as has been pointed out elsewhere, not infrequently usurp a tenanted woodchuck burrow, or make over a deserted system of tunnels, originally planned and executed by the woodchuck. Weasels, which are a far greater asset than has commonly been realized, utilize the shelter of woodchuck burrows for breeding purposes. Many other forms stay in the burrows of these creatures for short periods.

As a source of food, he is not without merit. Young woodchucks, properly prepared, are a joy to many country folk. Adults are prepared for winter use by the foreign rural population of central New York. Mr. Joseph Lisseck of Ithaca informs me that the Italians living near Danby, N. Y., frequently can woodchuck meat, preparing it in two-quart fruit jars for winter consumption.

The fur of the woodchuck is of little value, as it is thin, coarse, and not especially durable. The few coats I have seen made up of these skins were of spring pelts. If August or September animals had been used, and some care exercised in the matter of matching pelts, a fair garment, not unattractive, would result. Formerly the hide was tanned, and the tough skin made into straps or lacings for various uses on the farm. They are seldom used, even for such purposes, today.

The woodchuck's greatest value, from the viewpoint of the hunter, is the sport it furnishes. Woodchucks furnish more shooting, with a rifle, than any other mammal in the east, not excluding deer. They are the most abundant mammal, for their size, throughout settled

districts. A wary animal at the height of the best shooting season, July, August, and September, they offer a small mark from a long range. A head shot is usually necessary to stop the animal; less frequently, a bullet in the chest will kill it outright.

Both young and old are suspicious after the first mowing has been completed, and with less cover in which to hide, they utilize the early morning and late afternoon hours in which to venture forth. All individuals are not exceedingly wary, if they were the writer would never have had the large numbers to study that have been at his disposal.

It cannot be denied that all burrowing rodents play a considerable role in the formation of soil. Removing to the surface, as they do, the subsoil, stones, and inorganic matter in general, where the action of wind, rain, and frost, can work upon them more readily, it is inevitable that the period when such substances are transformed to finer, richer particles will be materially hastened.

In the west, where gophers, ground squirrels, and kangaroo rats, abound, this consideration is an important one. In his enlightening account of the burrowing habits of California rodents, Grinnell (1925) has shown that gophers will transport to the surface over seven tons of earth per square mile annually, where the animals are well represented. The same writer estimates ten burrowing mammals to the acre, as an average throughout the state. We have nothing paralleling this abundance in the east. Our commonest fossorial mammal, whose work is relatively obvious, is the woodchuck. In the southeastern states, where they are numerous, moles may play a factor in soil formation, but not on so grand a scale as those burrowers of the west.

Woodchucks are perpetual diggers. Their burrows are met with everywhere, when the animals are at all numerous. This tunneling brings stones, pebbles, clay, and sand to the surface, dependent on the type of soil in which they are working. This industry has a two-fold effect on the surrounding terrain.

First, the subsoil, being exposed to the elements, has an increased opportunity to become weathered, and transformed into arable land; secondly, air and water have freer access to the tunnels, where they may work together on the subsoil, breaking it up and comminuting large pieces. This all has a direct effect on the vegetation, resulting in increased growth.

We may assume that there is at least one woodchuck to the acre

over that part of their range in New York State where they are numerous. Each animal will bring to the surface, as determined by actual measurement, an average of two hundred pounds of dirt and stone during a single season. This gives a total of 128,000 pounds of subsoil transferred to the surface per square mile annually, where the atmospheric elements may get in their work of breaking up the particles. In other words, if we assume half of New York State, with its boundaries encompassing nearly 50,000 square miles, to harbor one woodchuck to every acre, we arrive at the astounding conclusion that over 1,600,000 tons of earth is removed to the surface each year. This is the equivalent of 32,000 loaded carloads each of fifty tons capacity. In some parts of the animal's range the amount of turnover is far in excess of the average, while large areas are devoid of all but a very few animals. The heavily timbered Adirondack region is a good example of the latter.

CONTROL METHODS

Essentially, there are three practical methods in vogue to keep the woodchuck population in check. Shooting, the use of gas in the burrows, and trapping, all have resulted in lessening their numbers for a short period. None of these, nor all combined, can ever exterminate the animal over a suitable range, or even materially reduce their numbers.

Shooting is, to the writer's mind, the most effective method of control. It must be understood that a good rifle, sound ammunition, and a capable marksman, all combine to make this method one of great destructive potentialities. The ideal time in which to carry on a warfare against this rodent, as it is with most rodents, is during the breeding season or somewhat previous to this, prior to the birth of the young. This covers a short period in early April in many instances, for young are born at any time during April and early May. To be effective, a head shot must be scored, for a woodchuck, possessed of remarkable recuperative powers, will survive a bullet wound almost anywhere else. A good rifle of .22 calibre is satisfactory, but one of a larger bore, such as a .25-20, a .32-20 or even a heavier weapon is more efficient. Telescope sights are an asset, as they prevent many misses and crippling shots. Woodchucks are remarkably free from suspicion in the early spring, and will show themselves repeatedly

although they have been fired at, again and again, without results.

The use of carbon bisulphide and calcium cyanide are both effective when gassing procedures are to be used. The former is placed on a piece of waste, cotton, or other absorbent material, three or four tablespoons being sufficient. Care should be taken to seal effectively the entrance to the burrow, using caution that no earth or other matter falls on the wad. Best results are obtained after a soaking rain, when the ground is well saturated. Smoking should not be indulged in when carbon bisulphide is being used, as it is highly inflammable.

Calcium cyanide, when exposed to the air, gives off hydrocyanic-acid gas. The powder is placed in a small pile far down the hole with a lath or spoon attached to a stick, or better, blown into the chamber with a foot-pump dust gun. Best results are obtained in dry weather.

Gassing kills all occupants of a burrow. If an inexperienced worker cannot readily differentiate between a tenanted woodchuck burrow and that of another animal, he had best not attempt this method of destruction. Many skunks and rabbits are killed each year by those who would destroy woodchucks by the use of gas.

Trapping is considered a satisfactory means of elimination. Steel traps of a large size are commonly employed. Woodchucks have a strength far greater than that of the other small furbearers of similar size, such as the skunk, fox, and racoon. Especially in the spring are they endowed with herculean powers, and will repeatedly make their escape from heavy traps, even those equipped with double springs. The commonest method, and by far the most effective, is to place two of these traps at a single entrance.

Trapping has the disadvantage of not being selective; the jaws of steel will close about the leg of a blundering skunk as quickly as they will snap at a groundhog. Often the skunk, possibly with young, will have such a mangled foreleg that killing is the only merciful solution. I have known young boys to trap as many as five skunks in a week's time during May, in their efforts to lessen the woodchuck population.

Constant warfare is essential. A large acreage may be successfully ridden of these rodents, only to find that the same fields are again well tenanted in short order, providing that neighboring fields and pastures have not been subjected to a like drive against these animals. There are always a good supply of occupied holes in each hedgerow bordering the fields. These are usually the homes of the larger animals,

which are warier and more difficult to destroy. Their offspring, or even themselves, will in time establish other home sites in the neighboring fields as the animals formerly occupying these areas are killed.

REFERENCES TO LITERATURE

Many papers have been consulted in the course of the present study. Some are so general in scope that they add nothing to our knowledge of the creature. This report consists of the writer's own notes on a part of the animal's life over a restricted area of its range. It does not pretend to be a monograph. In a life history study, there is generally little need to incorporate exhaustive paragraphs on the animal's range or on the various subspecies and the characters by which they are recognized. This phase of the woodchuck's history has been admirably treated by A. H. Howell (1915). For that reason the bibliography may appear short, but reference to the following papers will bring enough literature to light to cover rather thoroughly the phases of the animal's life not treated herein.

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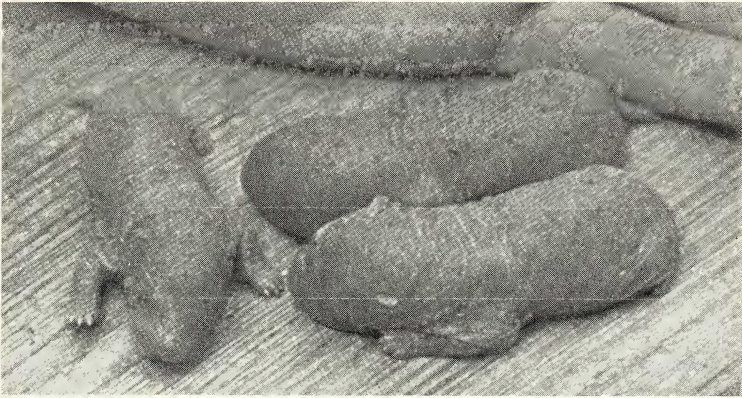
EXPLANATION OF PLATE XV.

FIG. 1. Young Woodchucks twelve hours after birth.

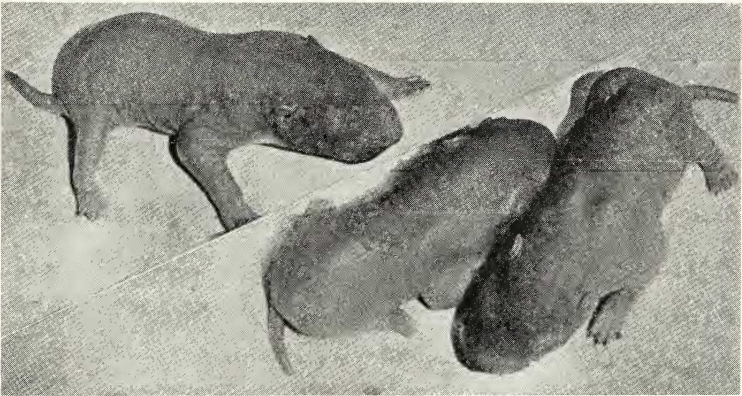
FIG. 2. Young Woodchucks one week old.

FIG. 3. Young Woodchucks two weeks old. Note grizzled snout.

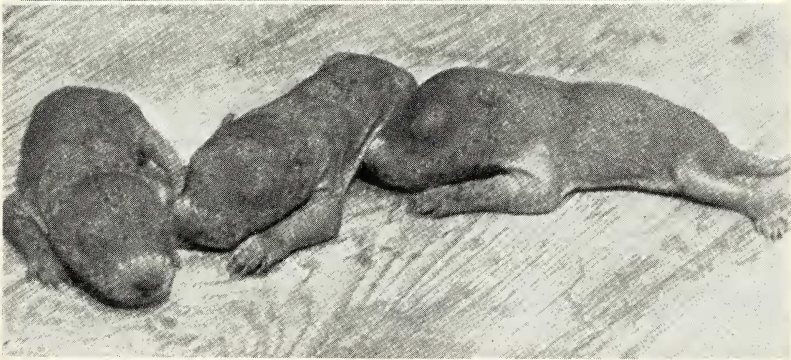
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For explanation see opposite page.

EXPLANATION OF PLATE XVI.

FIG. 1. Young Woodchucks three weeks old.

FIG. 2. Young Woodchuck four weeks old.

FIG. 3. Young Woodchucks five weeks old.

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For explanation see opposite page.

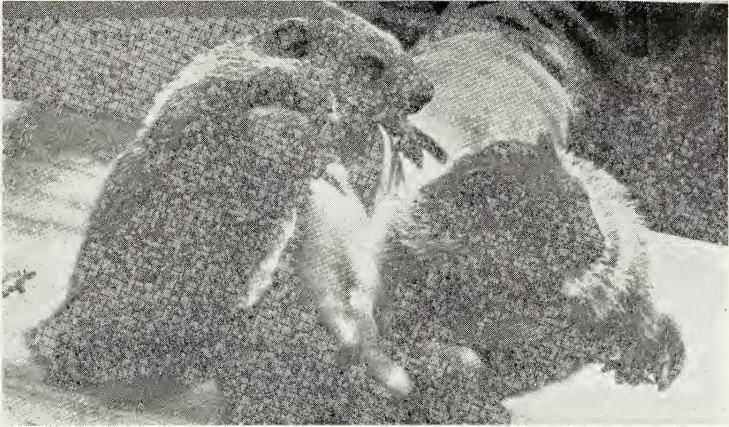
EXPLANATION OF PLATE XVII.

FIG. 1. Young Woodchucks seven weeks old.

FIG. 2. Young Woodchucks eight weeks old.

FIG. 3. Rearing Cages for Woodchucks. The nest chamber and pipe "burrow" are covered with straw when in use.

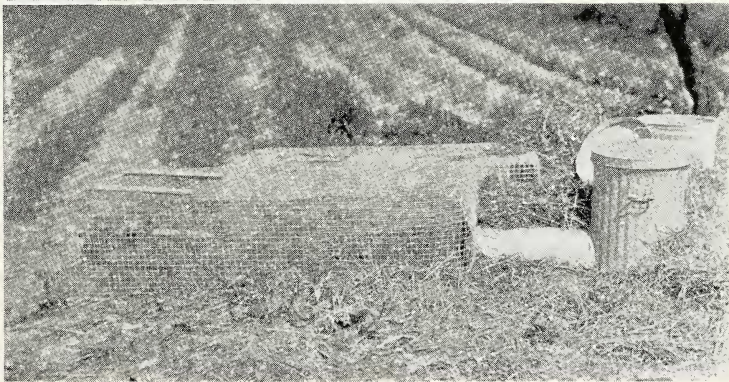
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